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The Climatic Causation of Consumption,

— WITH —

Tables and Diagrams Representing the Same.

Read in the Section of State Medicine at the Fortieth Annual Meeting of the American Medical Association, Newport, R. I., June, 1889.

BY HENRY B. BAKER, M.D.,
OF LANSING, MICH.

Reprinted from "The Journal of the American Medical Association," January 18 and 25, and February 1, 1890.

CHICAGO:
PRINTED AT THE OFFICE OF THE ASSOCIATION.
1890.

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PRESIDENT OF THE AMERICAN PUBLIC HEALTH ASSOCIATION

1889-90

PRESENTED TO THE MEMBERS OF THE A. P. H. A. WITH
THE COMPLIMENTS OF
THE ANNALS OF HYGIENE

THE CLIMATIC CAUSATION OF CONSUMPTION, WITH TABLES AND DIAGRAMS REPRESENTING THE SAME,

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In order that one may be justified in bringing here an elaborate paper with extensive tables and illustrative diagrams, it is incumbent on the writer to make sure that he has either facts of importance which have not been published, or such new mode of grouping facts previously known as shall yield new and useful knowledge, especially when, as in this instance, the title of the paper is similar to that of other papers by the same person. Therefore I hasten to assure you that there are included in and with this paper facts which, so far as I know, have not been published, and others which have not in connection with this subject.[1]

This grouping of evidences on this subject has for its main purpose the learning whether three important generalizations relative to consumption are antagonistic to each other, as has commonly been supposed, or whether there are facts which serve to bind them together and harmonize them, and thus make each of the classes of facts upon which these generalizations are based tend to support a still wider generalization, which shall include all the preceding ones.

The general law to which I shall first give attention is the one established many years ago by Dr. Henry I. Bowditch, of Massachusetts, and nearly the same time in England by Dr. Buchanan. I refer to the generalization that residence on low, moist ground tends toward the occurrence of consumption.

Next in order, and in connection with the first, I shall deal with a generalization to which, during recent years, I have myself been asking attention. I refer to the proposition that exposure to the inhalation of cold dry air tends toward the production of consumption—that, in fact, this is a *controlling* cause of the disease.

Thirdly, the dominant generalization of our own time, that consumption has one *specific* cause, and that cause the *bacillus tuberculosis*, will be considered, or at least acknowledged.

At first thought these three propositions appear to be incongruous, and I think there is generally an idea that only one of them can be true; but I may here anticipate one conclusion in this paper by saying that it seems to me that each one of these propositions rests upon a secure foundation, and that as soon as this is accepted as established it will be possible to hold a much more complete and useful view of the causation of consumption than has previously been possible—a view which shall recognize the facts (1) that inoculation of a susceptible animal with the *bacillus tuberculosis* generally tends to cause consumption in that animal; (2) that, notwithstanding a wide dissemination of this specific cause, accidental inoculation with it, or its permanent lodgment in the human

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[1] *List of Tables and Diagrams forming the Bases of the Evidence in this paper:*

Table 1 and diagram 1—Croup, and temperature in Massachusetts.
Table 2 and diagram 2—Croup, and absolute humidity in Massachusetts.
Table 3 and diagram 3—Consumption, and temperature in Massachusetts.
Table 4 and diagram 4—Small-pox, and temperature in Massachusetts.
Table 5 and diagram 5—Diphtheria, and temperature in Massachusetts.
Table 6 and diagram 6—Pneumonia, and temperature in Massachusetts.
Table 7 and diagram 7—Scarlatina, and temperature in Massachusetts.
Table 8 and diagram 8—Temperature, and sickness from pneumonia in U. S. armies.
Table 9 and diagram 9—Sickness from consumption in white troops, U. S. army, and temperature, 1862–5.
Diagram 10—Temperature, and deaths from phthisis in London, thirty years.
Diagram 11—Temperature, and sickness from consumption in Michigan.
Diagram 12—Bronchitis, and temperature in London.
Diagram 13—Sickness from croup, and temperature in Michigan.
Diagram 14—Temperature, and sickness from respiratory diseases in India, three years.
Diagram 15—Sickness from influenza, and temperature in Michigan.
Diagram 16—Sickness from tonsilitis, and temperature in Michigan.
Diagram 17—Temperature, and sickness from bronchitis in Michigan.
Diagram 18—Sickness from pneumonia, and temperature in Michigan.
Diagram 19—Absolute humidity, and sickness from pneumonia in Michigan.
Diagram 20—Pneumonia, and temperature in London, England
Diagram 21—Temperature, and sickness from scarlet fever in Michigan.
Diagram 22—Deaths from small-pox, and temperature in London, England.
Table 23 and diagram 23—Deaths from consumption in white troops in U. S. armies, and temperature.
Table 24 and diagram 24—Sickness from diphtheria, and temperature in Michigan.

organism, is more favored under certain climatic conditions than under others; (3) that even after its introduction and lodgment in the organism, residence in cellar-like places tends to make the disease more fatal than does residence in more elevated, well-drained, warm and sunny places.

It has been generally understood that there are influences associated with low and wet localities, and, by contrast, with high and dry localities, which it is especially important for mankind to learn and heed; and yet the systematic attempts to obtain a scientific knowledge of the nature of these influences, or even their extent, have been very few. Some years ago two prominent physicians, one in this country, Dr. Henry I. Bowditch, and one in England, Dr. G. Buchanan, almost simultaneously undertook to learn the influence of residence upon low, wet ground on that most important of all diseases, consumption. More recently Dr. William Pepper has attempted to collect the evidence on this subject throughout the State of Pennsylvania.

DR. BOWDITCH'S INVESTIGATIONS IN MASSACHUSETTS.

Dr. Bowditch has said that the two following propositions contain the essential points of his address on this subject:

First.—A residence on or near a damp soil, whether that dampness be inherent in the soil itself, or caused by percolation from adjacent ponds, rivers, meadows, marshes or springy soils, is one of the primal causes of consumption in Massachusetts, probably in New England, and possibly in other portions of the globe.

Second.—Consumption can be checked in its career, and possibly, nay probably, prevented in some instances by attention to this law.[2]

These lines of proof, or argument, are drawn from the following sources:

1. Massachusetts State registration reports.
2. Medical opinion of Massachusetts, as embodied in the returns made to me, as a committee of this Society, these returns consisting of written reports from resident physicians of 183 towns.
3. Actual statistics of deaths from consumption, received from such correspondents. Some of these statistics are but *incidentally* mentioned, while others are from towns, districted and carefully examined with reference to the relative prevalence of consumption in the different districts. In some of the most important of these the examination was made without my correspondent or myself being aware of the existence of any law such as that which I shall present at this time.
4. Peculiarities of certain towns and of villages in the same townships, in some of which consumption is quite prevalent, and in others much less so, these differences being connected most closely with corresponding differences in the amount of moisture of the soil of said places.
5. Certain well-known houses which, in various towns, are known by the inhabitants and physicians to have been long noted as the abode of consumption, and in some of which several families have been, during the past fifty years, cut off by the disease without the least suspicion on the part of the occupants of the fatal position in which the houses were placed.
6. Confirmatory facts, statistics and opinions from Rhode Island, Maine and New Hampshire.
7. The medical statistics given in the report on the health of the United States army, strongly supporting the idea of the existence of the same law and the operation of it over the whole of the United States.
8. Results of my own practice since I first became convinced of the truth of the law, said results consisting of (*a*) statistics from my private medical record; (*b*) results actually derived from my choice of localities for consumptive patients, based on a belief in the law.[3]

DR. BUCHANAN'S INVESTIGATIONS, IN ENGLAND.

Dr. Buchanan's very important contribution to our knowledge of this subject is so well summarized by Dr. William Pepper, that it seems best to quote from him, as follows:

The ninth and tenth reports of Mr. John Simon, Medical Officer of the Privy Council, contain the results of Dr. Buchanan's work, which was carried on in 1865, '66 and '67. Through this investigation it was discovered that in certain English towns where the drying of the subsoil had been accomplished by the construction of sewers, etc., and where the water supply had been improved, the mortality from phthisis had decreased. In Salisbury the death-rate from phthisis had fallen 49 per cent.; in Ely, 47 per cent.; in Rugby, 43 per cent.; in Banbury, 41 per cent.[4] In towns where no improvements had been made, or where the conditions were already good, there was no such corresponding change in the death-rate.

Dr. Buchanan summarizes the facts brought out in his investigation of phthisis in Surrey, Kent and Sussex, as follows:

There is less phthisis among populations living on pervious soils than among populations living on impervious soils.

There is less phthisis among populations living on high-lying pervious soils than among populations living on low-lying pervious soils.

There is less phthisis among populations living on sloping impervious soils than among populations living on flat impervious soils.

This connection between the iufluence of soil and phthisis was established by—

1. The general agreement in phthisis mortality between districts that have common geological and topographical features that are of a nature to affect the water-holding quality of the soil.
2. By the existence of a general disagreement between districts that are differently circumstanced in regard to such features; and
3. By the discovery of pretty regular concomitancy in the fluctuation of the two conditions from much phthisis with much wetness of soil to little phthisis with little wetness of soil.[5]

In his Tenth Report as Medical Officer, for 1867, Dr. Buchanan says:

But the connection between wet soil and phthisis came out last year in another way, which must here be recalled —(*d*) by the observation that phthisis had been greatly reduced in towns where the water of the soil had been artificially removed, and that it had not been reduced in other towns where the soil had not been dried.

5. The whole of the foregoing conclusions combine into one—which may now be affirmed generally, and not only of particular districts—that *wetness of soil is a cause of phthisis to the population living upon it.*

Dr. Buchanan quotes from the Seventh Annual Report of the Registrar-General for Scotland, from which I extract the following:[6]

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[2] Med. Com. Mass. Med. Soc., Vol. x, No. 11, 1862, p. 67.

[3] Med. Com. Med. Soc., Vol. x, No. 11, 1862, pp. 68--70.

[4] "Worthing, 36; Leicester, 32; Macclesfield, 31; Newport, 32; Cheltenham, 26. Bristol, 22; Dover, 20; Warwick, 19; Croydon, 17; Cardiff, 17; and Merthyr, 11;" according to the Medical Officer, page 15, Tenth Report Med. Officer of the Privy Council, 1867.

[5] Trans. Am. Climatolog. Assoc., May, 1886, N. Y., 1887, p. 89.

[6] Tenth Report Medical Officer, Privy Council, 1867, p. 109.

Let us see how such an explanation would agree with the very different proportion of deaths from consumption which occur in the eight principal towns of Scotland. Taking a five years' average (1857 to 1861 inclusive), it is found that, supposing all these towns are brought to an uniform population of 100,000 persons, there died annually from consumption 206 persons in Leith, 298 in Edinburgh, 310 in Perth, 332 in Aberdeen, 340 in Dundee, 383 in Paisley, 399 in Glasgow, and 400 in Greenock. The fact is, that if each town had been arranged in the order of comparative dryness of its site, they would almost have arranged themselves in the above position—Leith and Edinburgh the most free from consumption, and also having the dryest sites; Glasgow and Greenock the most ravaged by that disease, and beyond all comparison situated on the dampest sites. The above fact, then, with regard to the towns, corroborates, in the most striking manner, the conclusions of Dr. Bowditch, and should be a valuable help to the sanitary reformers, as to the very important measures which it is their more especial province to carry out.[7]

Referring to the conclusions based upon these investigations by Drs. Bowditch and Buchanan, Dr. R. Thorne Thorne, in his "Progress of Preventive Medicine during the Victorian Era," page 51, says:

I am aware that, in his sixth report (1879) on the Combined Sanitary District of West Sussex, Dr. Charles Kelly, basing his views on certain experiences derived from that rural area, has expressed a doubt as to the correctness of these conclusions. He says that the phthisis death-rate has been "distinctly lowered" in that district "in recent years," "while very little, if any, change has taken place during the same period in the drainage of the soil." Without entering into any criticism of some of the statistical data brought forward by Dr. Kelly in support of his views, I would here merely note, 1, that a large amount of agricultural drainage which had then already been effected throughout the kingdom would be expected to have produced a very similar result in rural districts to that brought about by sanitary drainage in towns; and 2, that Dr. Kelly offers no explanation of the definite and striking relations shown by Dr. Buchanan to have existed between the amount of diminution of phthisis death-rate and the extent and permanence of the lowering of subsoil water.

I have studied, with great interest, Dr. Kelly's "Sixth Annual Report," for West Sussex, published in 1880, as also one or two of his recent reports; and although I do not conclude that the facts and considerations he publishes controvert those published by Drs. Bowditch and Buchanan, they are of value, and especially in suggesting that coincidently with considerable progress in improved sanitary conditions of the surroundings, such as improved water supply, drainage, sewerage, etc., and improved methods of living, there has been apparently a great lessening of the mortality from consumption. Dr. Kelly says:

The great difference in the amount of consumption is probably dependent upon several causes. The improved state of the cottages, the rise of wages leading to the children being better clothed and fed, the increase in railway communication, which tends to diminish intermarriage, and to cause more interchange of population —all these changes, social as well as sanitary, have had their share in the improvement.

In his Fourteenth Annual Report, page 188, Dr. Kelly says:

It cannot be maintained that [all] deaths which used to be registered as phthisis are now included under lung diseases, because although there is an increase under the latter head, it is by no means equal to the decrease under phthisis.

Dr. Kelly, therefore, still claims that there has been an undoubted decrease of consumption in his jurisdiction.

Dr. Kelly's results reinforce the evidence heretofore collected, as to the influence of nearly all sanitary improvements in decreasing consumption, but they do not seem to me to have any force toward breaking down the evidence collected by Drs. Bowditch and Buchanan.

DR. PEPPER'S INVESTIGATIONS, IN PENNSYLVANIA.

Dr. Pepper's "Climatological Study of Consumption in Pennsylyania" seems to have been well planned, and carefully executed, but it did not yield results as convincing on the subject of the relation of soil moisture to consumption as did the investigations by Drs Bowditch and Buchanan, probably because of less perfect records of vital statistics in Pennsylvania, and perhaps also because of less attention having been given to the subject by local physicians in that State.

A few selections may be instructive:

It will be observed at once that those portions of the State where phthisis is rarest are the most elevated, having a general altitude of 1,500 to 2,000, or, better still, of 2,000 to 3,000 feet; while, in proportion as we enter districts of lower general altitude, we find correspondingly increasing rates of mortality from consumption.[8]

It may be noted that in Erie county, which has considerable average elevation, the mortality may be influenced by the proximity of the lake, and by the presence of a considerable body of low, wet land.

It will be seen further on, in the more minute study we have been able to make of Philadelphia, that the influence of elevation and of density of population appears to be considerable, and in accordance with what we have above stated.[9]

Dr. Bowditch and Dr. Buchanan each gathered evidence, from several sources, the combined force of which was very great, and after their results were united their conclusions were irresistible. As they have never been successfully controverted, it seems probable that the laws which they formulated will stand as a secure foundation upon which we may safely build. Wm. Pepper, M.D., LL.D., the distinguished Provost of the University of Pennsylvania, has said:

It is manifestly difficult to subject this theory to searching and conclusive investigation; but, so far as investigation has been made in other portions of this country or abroad, the evidence has tended to confirm Dr. Bowditch's position.[10]

But, if the grand truth, for which we are so much indebted to him, is really a truth, how comes it that the great reduction in consumption which should have followed its discovery has been as yet so little realized? There are, prob-

7 Tenth Report Medical Officer, Privy Council, 1867, p. 110.

8 Trans. Am. Climatological Assoc., May, 1886. New York, 1887, p. 98.

9 Page 99.

10 Trans. Am. Climatological Assoc., 1887, p. 88.

ably, several reasons, such as the slow progress which any such truth has in gaining acceptance, even among the thinking classes; but, in my opinion, one chief reason for the non-acceptance of, and for the non-action in accordance with this great discovery, was the fact that no one knew the *reason why* residence on or near low, wet soil was a prominent cause of consumption. The assertion and proof that this was a true law, when no one could imagine a reason why, has not led to its acceptance in such a hearty manner as to make it a strong factor in controlling the actions of residents of even New England. So that, although the death-rate from consumption in many parts of New England has steadily declined, it has not declined as fast as a knowledge of such an important general law as that propounded by Dr. Bowditch might have led one to expect; and it is with a feeling of sadness that one knowing this must now read the lines written by Dr. Bowditch over a quarter of a century ago, and which glow with lofty sentiments of manly enthusiasm. Not but that *his* work was well and nobly done, but the sadness comes because mankind is so slow to heed the warnings of its best prophets. Dr. Bowditch said:

When I revolved in my mind the possibility of this being an exact representation of a great truth, and then thought of the vast influence the thorough knowledge of it must have upon our professional practice, and of the beneficial effects upon public hygiene that would perhaps result, *in future*, from an intelligent obedience to it by the community at large, it was the happiest and most satisfactory moment of my professional life. I remembered that over twenty thousand[11] consumptive patients had died in Massachusetts during the previous five years. I asked myself these questions: Supposing this township represents the various townships of the State, and that they all have their varieties of soil, then if this township's statistics are true, and at least twice as many die in the wet as in the dry districts, may not similar results have occurred and perhaps be still occurring all over the State in which these twenty thousand human beings have been slain? Having arrived at this point, you will not be surprised at my asking, still further, this pregnant question: If our fathers and we had paid greater attention to this law, and we had always resided in dry localities, leaving the lower and moister for the purposes of business, perhaps, during the day, or for agriculture, should we not be saving over one thousand lives annually in Massachusetts, which are now foolishly sacrificed? These questions I then answered but imperfectly, but statistics since received, and of which I shall hereafter give you, I hope, more convincing examples, have only made me, each year, more firm in the conviction of the affirmative of these questions, at least in all their essential elements.[12]

The writer of this article accepts the evidence collated by Dr. Bowditch in Massachusetts, by Dr. Buchanan in England, and by Dr. William Pepper in Pennsylvania. I accept it because it seems convincing, because it has not been controverted, because it is in harmony with the several lines of evidence which I myself have collated, and because I think I know *why* it is true; and one chief object of the preparation of this essay is the hope that the reason why may be made plain, and that thereby the realization by mankind of the grand results aimed at by Dr. Bowditch may be aided.

In order to learn the reason for the truth set forth by Dr. Bowditch, let us first inquire what are the principal meteorological differences between high and dry localities, and low and wet localities.

CLIMATIC CHARACTERISTICS OF LOW AND WET, AND OF HIGH AND DRY LOCALITIES.

Atmospheric Pressure.—It is at once apparent that between "high" and "low" localities there is, of course, the difference in atmospheric pressure; but the difference in atmospheric pressure due to the few feet difference in elevation between the best and the worst localities studied by Dr. Bowditch could not have had great influence.

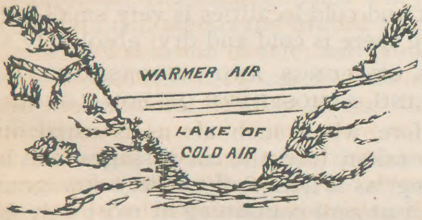
Atmospheric Humidity.—The next most noticeable element is the atmospheric moisture; and here, in my opinion, we strike the point from which our friends, in times past, have almost uniformly diverged from the path which would have led them to the truth. They have assumed, apparently, that a wet *soil* always tends to make a moist *atmosphere* over that soil, and although this is true if we speak only of the *relative* humidity (which is the per cent. of saturation of the air with vapor of water), it is not true if we speak of the *absolute* humidity (which is the amount of vapor of water which the air actually contains). Our predecessors have uniformly considered only the relative humidity, while, as I hope to show, it is mainly the absolute humidity that has influence in the air passages; for the reason that the air exhaled, having been in contact with the warm and moist surfaces in the lungs and air passages, leaves the body, uniformly, summer and winter, at about the same temperature—near 98° F., and nearly saturated with the vapor of water at that temperature. According to Glaisher's and Guyot's tables, air at 98° F., saturated with vapor, contains about 18.69. grs. of vapor in each cubic foot of air. This being so, the quantity of moisture taken out of the lungs and air passages in excess of that inhaled depends, not upon how nearly saturated with vapor the air may be when it is inhaled—not upon its relative humidity, because if saturated at zero it can contain only ½ gr. of vapor, at 32° only 2 grs., at 70° 8 grs., etc.—but the quantity of moisture exhaled in excess of that inhaled mainly depends upon the *absolute* humidity of the atmosphere. If air at zero, saturated with vapor, is inhaled, each cubic foot of it when exhaled will abstract from the lungs and air passages about 18 grs. of vapor of water.[13]

What are the important influences connected

[11] In Registration Report, 1857, we find that during the five years including 1853 to 1857, 23,280 died of consumption in Massachusetts.
[12] Med. Com. Mass. Med. Soc., Vol. vi, Part ii, 1862, pp. 88, 89.

with the excessive exhalation of water from the air passages?

Atmospheric Temperature.—Before answering the foregoing question, however, let us fully understand why it is that residents over a cold *damp soil* are surrounded by an *atmosphere* which is cold and *dry*, absolutely, and which takes *out of the lungs* and air passages *larger* quantities of moisture than does air over a warm and dry soil. The main reason is that the atmosphere over low and wet soil is nearly always cold, as will presently be made apparent. And, as already pointed out, cold air is always, necessarily, dry air, so far as relates to the absolute quantity of moisture; although, because its capacity to hold moisture is slight, and because it has usually been cooled from a higher temperature, in which condition it held more vapor, cold air is frequently saturated with moisture—its *relative* humidity is great, but its *absolute* humidity is small. On the other hand, the atmosphere over high and dry localities is generally warmer, especially when the air is still (as it usually is at night), because then the cold air, being heavier than warm air, settles down into the valleys, and flows along water-courses, while the lighter warm air rises and remains on a higher plane. The sensations of any ordinarily sensitive person are sufficiently acute to detect the cellar-like atmosphere of the valleys and water-courses, on still evenings, when one goes down into them from the higher levels; and the sudden transition from such coolness to noticeable warmth is often very apparent to one who ascends directly from the low levels to a hill top.



A COLD VALLEY.

In speaking of a house in which a case of consumption originated, Dr. Bowditch described the locality as follows:

> On each side of this valley arise high and sandy hills. With each evening sunset, a flood of cold moisture, almost if not quite imperceptible to eyesight, but quite palpable to the sensitive skin of the traveler, settles in between the hills and gradually envelops this devoted house. I have often passed the spot late at night. At times the moon shone clearly on the immediately adjacent ridges, but as I descended from them and passed the house, the rays were obscured, and a chilly feeling came over me, as if taking a cold bath.[14]

While the sun shines, the valleys are frequently warm, and the valleys and low levels are frequently protected from winds, yet, as soon as the sunshine is withdrawn, the general law that warm air is lighter than cold air results in there being *generally* a lake of cold air in all basin-shaped localities, in there being streams of cold air flowing down[15] water-courses, and, generally, in the accumulation of cold air over every locality which is sufficiently basin-shaped that it retains water in or upon the soil. This is one reason why a low, wet place is generally cold. Another reason is that the evaporation of water produces cold, therefore, whenever the atmosphere is not fully saturated with vapor of water, a wet locality is for this reason colder than a dry one. This is one reason why underdraining a soil makes it warmer.

Frosts in Low, Wet Localities.—The fact that low, wet localities are generally cold is of such importance that I do not wish to slur it over, but to present sufficient evidence to make it conclusive. One line of evidence is that of the effect on tender vegetation. The fact that a "killing frost" occurs on low, wet places frequently when the uplands escape, is well known. It is also well known that, in districts where peach trees are grown, peach orchards on the hills frequently escape when those on the low lands are killed by the cold.

Thermometric Observations, on Low Lands.—Experiments made a few years ago by Prof. R. C. Kedzie, at the Michigan Agricultural College, *proved* that self-registering thermometers exposed on the high ground registered a higher temperature, by several degrees, than those exposed on adjacent low grounds; and that the cold air apparently flowed down the natural water-course through the grounds. Comparative observations made by Mr. W. C. Haines, at Lansing, Mich., prove that in a valley, along the bottom of which runs a small stream, a self-registering minimum thermometer (which had been compared with a standard instrument), generally shows the minimum temperature, even in winter months, to be lower than it is on the high ground in the State Capitol Square, in the same city, the difference in the *elevation* being only about 25 feet.

The Atmosphere at Low Levels is Coldest at Night.—The greater cold at low levels is most frequently at night; and it is worthy of note that it is *at a time when artificial heat is not usually employed;* and, although one may be warmly covered in bed, no method has been in very general use for the warming of the air inhaled under such circumstances, so that the lungs and air passages are more influenced by cold nights than by cold days.[16] Observations made for the Royal Meteorological Society of London, England,[17] at Boston, Lincoln-

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[13] If air at zero is warmed without being supplied with moisture, and then inhaled, its drying effects on the air passages will, of course, be the same as if breathed at the low temperature.

[14] Med. Com. Mass. Med. Soc., 1862, p. 93.

[15] If the wind is up stream, the flow of cold air may be up stream; but see results of Prof. Kedzie's experiments mentioned further on, under the heading: "Thermometric Observations on Low Lands."

[16] The curve for ozone at *night* in Michigan is almost precisely the same as the curve representing sickness from pneumonia.

[17] Quar. Jour. Royal Met. Soc., October, 1887, p. 275.

shire, 4 feet from the ground, and at 170, and at 260 feet from the ground in the church tower, and which the Secretary of the Society says are "superior to any observations heretofore made," show that—

The *minimum* temperature at 4 feet is generally colder than at 170 feet, except in winter months, when the latter is generally colder than the former. . . . The mean temperature at 4 feet, during the day hours, is always in excess of that of 260 feet, the difference during the summer months amounting to about 4° at the warmest part of the day. *As night comes on the difference becomes less.*[18]

The general results therefore show that the diurnal range of temperature is much less at the top of the tower and on the belfry than at 4 feet above the ground. . . .

In foggy weather the temperature at the top of the tower is always warmer than at 4 feet, the upper part of the tower being generally free from fog.[19]

Fogs over Low Lands.—As illustrating the fact that fogs are most frequent over low, wet and cold levels, the remarks by the Secretary of the Royal Meteorological Society are applicable. He says: "The object of the Council in transferring the instruments to Lincoln was to obtain results from a differently situated place. The base of Boston Church was only a few feet above sea level, and the country round was very flat, while Lincoln Cathedral was situated *on a hill and was thus free from the ground fogs which so frequently occurred at Boston.*[20]

It is proper to state that Dr. Bowditch has said:

While claiming dampness of the *soil* as *one of the prime causes of consumption in New England, I do not assert that it is the sole cause, or that the combination of changeableness and coldness with moisture, may not be vastly more fatal than moisture alone.*[21]

Hillsides are Warmer than Low Levels.—It will be seen by the careful student that Dr. Buchanan carried the investigation, or at least his exact summarizing, further than Dr. Bowditch did; and, although *he* has not taught us what there is about wet, low-lying soils that causes phthisis, he has supplied us with one very important generalization, namely: "There is less phthisis among populations living on sloping impervious soils than among populations living on flat impervious soils.[22] In the light of what has been pointed out in this essay, the reason for this now seems obvious—the sloping impervious soil permits the cold overlying atmosphere to fall into the valleys below, while the flat impervious soil not only retains its own cold atmosphere but tends to send up the slope its warmest air, and to take in exchange the coldest and heaviest atmosphere from the surrounding slopes. Although Dr. Bowditch did not in his summary clearly state the generalization that *sloping* impervious soils are not as dangerous as *flat* impervious soils, portions of his address show that he held it in mind, for he says:

[18] Same page—275. Italics mine.
[19] Quar. Jour. Royal Met. Soc., October, 1887, p, 277.
[20] Same Vol., p. 280. Italics mine.
[21] Med. Com. Mass. Med. Soc., Vol. x, No. 11, 1862, p. 90.
[22] Trans. Am. Climatol. Ass'n, 1886. New York, 1887, p. 90. The original is in paragraph 3, on page 109. Tenth Report of the Medical Officer of the Privy Council, 1867, London, 1868.

I believe that all towns, parts of towns, houses even that *rest on* damp, cold soils, are by that very fact liable to the prevalence of consumption. I believe that similar locations *near* wet meadows, rivers, marshes, etc., though less subject to the law, are nevertheless, in a lesser degree, promoters of consumption in the families resident thereupon. Even hills, with clayey subsoil retaining moisture, though not absolutely evil, are less good than a perfectly dry, porous soil, removed from any moisture.[23]

Again, in speaking of choosing a site for a dwelling-house, Dr. Bowditch says:

It should be in a portion of the township which is neither so high as to be exposed to violent gusts of weather, nor so low that moisture will collect around it. Let it be on the side of a hill, or plain, open to the south, and, if possible, defended from the north and east, on a dry, porous soil, through which water freely percolates, and which, even after a rain, retains little moisture.[24]

SUMMARY: ELEMENTS OF CLIMATE CHARACTERIZING LOW, WET LOCALITIES.

Perhaps this part of the subject has now received sufficient attention to have established the points which it seems important should be understood, namely:

1. That the *atmosphere* over low and wet localities is *cold*, especially *nights* when, because of there frequently being no fires, the lungs and air passages are in most danger of injury, by the inhalation of cold air.

2. That the atmosphere in such localities is, more frequently than at higher levels, saturated with vapor of water, as shown by psychrometric observations, and also by the presence of fogs, etc., and, what is most important—

3. That, because the capacity of cold air to contain vapor of water is very small, the absolute quantity of water contained in the atmosphere in low, wet and cold localities is very small—the atmosphere there is cold and dry, absolutely.

EFFECTS ON LUNGS AND AIR-PASSAGES OF INHALING ATMOSPHERE OF LOW LEVELS.

Therefore, when such air as is usual on low levels is taken into the air-passages and lungs, containing, as it does, only a very few grains of vapor (air at zero containing at most only half a grain to each cubic foot), and is exhaled saturated with moisture at about 98° F. (each cubic foot of air then containing 18.69 grains of water), an excessive quantity of moisture is abstracted from the lungs and air-passages and an excessive quantity of the non-volatile salts of the blood (which pass into the air-cells from the blood with the fluid which normally keeps the air-cells moist), an excessive quantity of these salts is left in the air-cells and on the mucous lining of the air-passages. This is not stated on hypothesis alone, although this conclusion was reached *a priori* from causes known; but it has since been *proved* to be true by reliable and sufficient statistics of sickness and of coincident meteorological conditions, and by chemical analyses of the lungs and

[23] Med. Com. Mass. Med. Soc., Vol. x, No. 11, 1862, p. 122.
[24] Page 124.

sputa. Thus, by abundant statistics I have proved[25] (and the evidence with this essay tends strongly to support this view) that at such times as pneumonia, bronchitis, influenza and other diseases of the throat, lungs and air-passages most prevail, the atmosphere is cold and dry (absolutely, although the relative humidity or per cent. of saturation may be great). Dr. Redtenbacher,[26] in 1850, and since him many another person, has shown that during the onward progress of pneumonia chloride of sodium, which is normally present, disappears from the urine. Lionel Smith Beale, M.B., has shown[27] by analyses that the chloride of sodium which, during the onward progress of pneumonia, disappears from the urine, is found in the sputa and in the solidified lung. It is therefore *proved* that just preceding the greatest prevalence of these irritative and exudative diseases of the lungs and air-passages the air inhaled is unusually dry, that the evaporation of moisture and, by inference, the quantity of non-volatile salts left thereby, is unusually great; and that, as proved by analyses, the chlorides are in the sputa and in the solidified lung in unusual proportion; that, notwithstanding the action of the lymphatics, these irritant salts accumulate there. The irritation of influenza, the bronchial cough, the exudation on the surface of the air-passages and sometimes into the air-cells, under such circumstances does not, therefore, seem wonderful. It seems now to be explained. Yet there is still more evidence connecting the presence of sodium chloride in the fluids which moisten the air-passages with the exudation of the albuminous constituents of the blood serum. Experiments by Brücke and afterward by Hoppe[28] have proved that although albumen will not pass through an animal membrane toward pure water, it will pass to a solution of salt; and Hoppe's experiments proved that the passage of the albumen is in proportion to the rapidity of the movement of the fluid.[29]

It would seem, therefore, that the more rapid the evaporation of fluid from the air-passages, and the faster the fluid is exuded toward the unusually strong solution of sodium chloride in the air-cells, the greater the proportion of albumen which will exude into the air-cells. This has an important bearing upon the causation of consumption, because it is quite a common belief, resting upon many observations, that consumption not infrequently follows exposure to taking "cold." Besides, from the work of Prof. R. Koch and others it seems that we must conclude that the introduction into the body of a susceptible person of the *bacillus tuberculosis* is generally followed by tubercular consumption. Therefore, as an albuminous exudate on an irritated or inflamed surface in the air-passages, maintained at the temperature of the human body, supplies a "culture fluid" and temperature conditions which are well known to be favorable to the reproduction of the *bacillus tuberculosis*, it follows that exposure to the inhalation of those bacilli at such times as such an exudate is present in the air-passages must lead to a larger than the average proportion of instances in which such bacilli are enabled to gain a successful lodgment in the air-passages. And since it has been proved that inoculation with the *bacillus tuberculosis* in other parts of the body is not infrequently followed by tuberculosis of the lungs, it seems to follow that the bacilli are caused to exude into the air-passages (brought there from tuberculous foci in other parts of the body); and it would seem that they would be most likely to be exuded, and, if exuded, to maintain a lodgment there at such times as exudation into the air-cells or air-passages is greatest. Therefore, consumption of the lungs should be contracted most readily at such times as croup, influenza, bronchitis and pneumonia occur. Let us examine the evidence of our vital statistics, in order to ascertain whether or not this hypothesis is in accordance with the facts.

DO IRRITATIVE, EXUDATIVE DISEASES OF THE AIR-PASSAGES AND LUNGS ACCOMPANY OR PRECEDE CONSUMPTION?

At the outset we are met with the difficulty that in most States and countries no sufficient statistics of *sickness* are recorded; but inasmuch as the same course of reasoning, as to the favoring of the reproduction of the bacilli in the lungs and air-passages by the occurrence of a saline and albuminous exudate, will apply to the later stages of consumption as well as to the first, it follows that the *deaths* also from consumption should be most frequent following the occurrence of those conditions which cause the exudative diseases of the air-passages.

For the purpose of answering the above question, and to supply the evidence on which this essay is mainly based, twenty-four tables and twenty-four diagrams, accurately drawn to scale and graphically exhibiting the essential facts contained in the tables, are submitted herewith. The first seven tables and diagrams show the relations which the deaths reported from consumption and from each of several diseases in Massachusetts sustain to those from each of the other diseases and to the atmospheric temperature. And since the absolute humidity of the atmosphere is so greatly controlled by the temperature, and the curve for absolute humidity in this part of the world, as shown by a comparison of it in diagram No. 2 with the curve for temperature in diagram No. 1, is almost the same as the curve for tem-

[25] Proceedings Mich. State Board of Health, Oct., 1886, pp. 7--11; Trans. Am. Climat. Assoc., May, 1886, New York, 1887, pp. 226--233; Mich. State Board of Health Report, 1886, pp. 246--324; 1887, pp. 197--211; 1888, pp. 143--169.

[26] Zeitschrift der K. K. Geselschaft der Aertze zu Wien, Aug., 1850.

[27] Trans. Medico-Chirurg. Soc., Vol. xxxv, 1852.

[28] Virchow's Archiv, Vol. 9, 1856, pp. 245--268.

[29] Virchow's Archiv, Vol. 9, 1856, pp. 265--267.

perature, the several diagrams also show, to whomsoever will hold these facts in mind, the relations of the deaths reported from the several diseases to the *absolute humidity* of the atmosphere. For one disease, croup, diagrams 1 and 2 illustrate these relations fully.

In studying the relations of the several diseases it should be borne in mind that the average *duration* is not the same for all; therefore, it cannot be expected that there would be exact uniformity—that the time between the exposure to the cause and the fatal result shall be the same for all diseases. Bearing this in mind, an examination of the several diagrams shows that these diseases sustain such relations to the temperature and absolute humidity of the atmosphere as to indicate that these conditions are causal.

A very noticeable departure from quantitative relations—the same in different parts of the year—is to be seen in the diagrams relative to croup, consumption and diphtheria, and is slightly apparent in the curves relating to small-pox. It is a *lower* curve than proportional in those months when the atmosphere is becoming more warm and moist, and a *higher* curve in those months when the atmosphere is constantly becoming cold and dry. It is as if those who were injured by a very cold dry air do not die if warmer weather ensues, and those taken sick in comparatively warm weather die in unusual proportion in the autumn months, as the weather constantly becomes colder and drier. This is strongly marked in diagram No. 3, relating to consumption. In that diagram, considering the fact of the general relations of the two curves, there are also hints that possibly consumptives guard against exposures more success fully in the coldest months. It is quite possible, and I think probable, that these statistics of deaths from consumption in Massachusetts in recent years are modified by the great numbers of consumptives and persons with susceptible lungs who leave that State in the autumn and do not return from their southern trip until spring. This becomes more apparent when one compares diagram No. 3 with diagrams exhibiting the curves for consumption in some other parts of the world, although the same principles seem to hold, to some extent, in most cases; but in the diagrams of deaths and of *sickness* from consumption in the United States armies during the war of the rebellion it is much less apparent than it is in the diagram (No. 3) relative to deaths in Massachusetts.

Turning now to the more extensive mortality statistics in London, England, it is seen, by a glance at the several diagrams (diagrams 10, 12, 20, 22), that the curves for the diseases of the lungs and air-passages follow the curves for atmospheric temperature with such uniformity as to indicate quantitative causal relations. That the curve for consumption in London (diagram No. 10) does not fall so noticeably as it does in Massachusetts in the winter months, may be, in part, due to the fact that the statistics extend back to a time when journeys southward in the autumn were not so much the custom as at present.

The diagrams show that in London the deaths from consumption do follow, from one to three months later, the deaths from bronchitis and pneumonia.

Tables and diagrams 8, 9 and 23 exhibit the facts respecting the rise and fall of the *sickness* from pneumonia and consumption, and the *deaths* from consumption in the United States armies during the war of the rebellion. The statistics are quite extensive, and as they exhibit the facts relative to the sickness as well as the deaths, they are especially valuable. It will be seen that the sickness and the deaths from consumption do in general follow the sickness from pneumonia; also that the sickness from pneumonia follows the changes of atmospheric temperature with such closeness and regularity as to show that, directly or indirectly, the temperature sustains causal relations.

That the control of diseases of the air-passages by atmospheric temperature is not confined to this country and England, but applies also to countries having very much warmer atmosphere, is proved by the table and diagram No. 14, which show that in India the diseases of the air-passages (not including consumption) are controlled by the temperature.

Finally there are submitted herewith tables and diagrams (Nos. 15 to 21 inclusive) proving that in Michigan (in which State valuable statistics of *sickness* are collected) the *sickness* from nearly every one of the entire class of diseases of the air-passages and lungs is controlled by the atmospheric temperature, and that the sickness from consumption follows, in general, the law which has herein been pointed out.

In all the countries, States, cities and armies concerning which I have thus far studied the statistics relating to this subject, the same law seems to hold: a very considerable proportion of the *sickness* and the *deaths* from consumption follow, or sustain such relations to, the irritative and exudative diseases of the air-passages and lungs as to prove a necessary or causal relation; and these other diseases of the air-passages and lungs are quantitatively related to the temperature and absolute humidity of the atmosphere, proving that, directly or indirectly, they are controlled by these atmospheric conditions. I have pointed out how, in my opinion, this occurs, namely, indirectly through the absolute humidity of the atmosphere, which, so far as its maximum is concerned, is absolutely controlled by the temperature, cold air being always necessarily dry air.

Nor is this all of the evidence. As elsewhere pointed out, it is proved that the deaths from

small-pox follow the same law, as should, theoretically, be the case, because the same remarks, as to the saline and albuminous exudate in the air-passages at the temperature of the body being the best possible "culture fluid" and temperature conditions for the specific cause of consumption, apply as well to the specific cause of small-pox. Therefore, the accompanying tables and diagrams (4 and 22) on this subject are submitted in this connection.

The fact that small-pox and other diseases known to be communicable and to enter the body by way of the air-passages are in great part controlled by the atmospheric temperature, as is shown by diagrams 4, 5, 7, 22 and 24, is, by itself, strong presumptive evidence that such a disease as consumption, a disease in which also the specific cause is believed frequently to enter the body by way of the air-passages, will be controlled by similar atmospheric conditions.

A comparison of diagrams 10 and 22 shows that the curves for deaths from small-pox and consumption in London, England, are almost identical. This must have come about through the inhalation of cold air, which led to irritations and exudations in the air-passages and lungs, and thus favored the contraction of both of these diseases; but, inasmuch as otherwise we would admit that the average duration (of the periods of incubation and of the diseases) was the same in both diseases, it would seem to be proved that the progress of the *later* stages of consumption also is influenced by the irritation and exudations caused by the inhalation of cold air. How this is possible has already been explained.

A LARGE PROPORTION OF THOSE WHO HAVE CONSUMPTION RECOVER.

That there are conditions under which human beings recover from consumption seems to be well proved by many observers. Dr. H. P. Loomis, of New York, is recently reported to have stated that "in no less than 60 per cent. of all patients dying at Bellevue Hospital there were old tubercular changes in the lungs, the disease having been recovered from."[30]

If 13 or 15 per cent. of all deaths are from consumption, and 60 per cent. of those who die of other diseases have had consumption, or at least "tubercular changes in the lungs," from which they have recovered, it would appear that the specific cause gains a lodgment in 73 per cent. of all persons, and proves fatal in only about 13 or 15 per cent. of all persons. This has an important bearing upon the view that the *bacillus tuberculosis* is the only cause which it is worth while to study. A recent writer, speaking of tubercular phthisis, said: "In the autopsies made at the Philadelphia Hospital it is surprising to see the almost universal presence of this disease, in a more or less active state, in patients dying from other affections, such as Bright's disease or carcinoma.[31]

Dr. E. L. Trudeau, of Saranac Lake, N. Y., has said:

> Vibert recently, while making 131 autopsies at the Paris morgue on persons who had come to their death by violence while apparently in good health, noted in twenty-five—that is, in more than nineteen per cent.—the presence of some slight tubercular lesion. In seventeen of the twenty-five a few calcarious and fibrous nodules remained as the only evidence of an unsuspected and arrested tubercular process, but in none were the pathological changes in the lungs extensive. Recovery often follows the operations now undertaken for tubercular peritonitis, though it is evident that all the infectious material cannot be removed.
>
> The records of the autopsies made by Vibert, Councilman and others, as well as the evidence offered by the present research [Dr. Trudeau's experiments on the influence of environment on consumption], furnish proof that the tissues themselves can, under certain conditions, either limit the destructive action of this microbe [*bacillus tuberculosis*], or even entirely rid themselves of its presence.[32]

The experiments by Dr. Trudeau on the influence of environment on the course of tubercular disease artificially induced by the inoculation of animals (published in the "Transactions of the American Climatological Association" for 1887 and 1888) have demonstrated, apparently, that something similar to what has been set forth by Drs. Bowditch and Buchanan as true of the influence of climatic environment on mortality from consumption in the human species, is true relative to animals. Rabits inoculated with the *bacillus tuberculosis* and kept in a cellar-like place on restricted diet, died of the disease in much greater proportion than did similar animals similarly inoculated but kept in the open air with abundance of food. Under such favorable conditions a large proportion of the animals recovered so far, at least, as to maintain good health, although the local infection was not destroyed, but only circumscribed.

THE CAUSATION OF CONSUMPTION IS COMPLEX.

It seems to be difficult for the human mind to grasp more than one idea at a time. Accordingly we find a strong tendency to assume that there is and can be but *one* cause or essential condition leading to consumption; but nothing is more certain than that the forces and reactions in nature are complex, and to me the evidence is conclusive that the causation of consumption is complex. But, although complex, I believe the problem is now quite within our grasp, in all its most important features, if we only hold fast to the truths we have learned of the relations of consumption to low, wet places, while we grasp the obverse idea of the favorable influences of high, dry and sunny places; hold fast to this double image of one great truth, while we lay hold of that one

30 Jour. Am. Med. Assoc., May 18, 1889, p. 718.
31 J. H. Musser, M.D., reported in the Medical and Surgical Reporter, Philadelphia, Jan. 26, 1889, p. 102.
32 Trans. Am. Climatolog. Assoc., 1888, pp. 93–94.

which teaches us the great importance of proper clothing, food and all that goes to make the nourishment of the body fully equal to all demands upon it; hold fast to this rather complex thought while we grasp the great truth which Dr. Robert Koch has given us, that there is a specific cause which *under favoring circumstances and conditions* is an essential factor in the causation of consumption ; and, while holding all this in mind, I ask you to consider how it is that this specific cause usually enters the body, and the fact that just as the specific causes of many other diseases (as is proved by the statistics of sickness and deaths which I present to you at this time), just as they enter and cause the disease in proportion to the coldness and dryness of the atmosphere, so the specific cause of consumption apparently and probably finds lodgment in the lungs and air-passages, other things being equal, in proportion to the coldness and dryness of the atmosphere ; and not only this, but the danger of auto-infection and of death to one in whose body the disease is already present is increased by exposure in an atmosphere unusually cold and dry, while the condition of the blood is such that saline and albuminous exudates are liable to occur in the air-passages.

Finally, in order to grasp the most at once, we need to link the facts together, realizing the fact that over the low *wet soil* there is generally a *cold, dry atmosphere*, thus making it plain that the facts observed and collated by Drs. Bowditch and Buchanan are entirely in harmony with those observed by Dr. Koch, and with the enormous numbers of facts which I have tabulated, and which prove beyond question that there is a causal relation between the inhalation of such an atmosphere and the occurrence of all the ordinary diseases of the air-passages and of those communicable diseases which enter by way of the air-passages, including tubercular consumption.

ONE RELATION OF STATISTICS OF CONSUMPTION TO STATISTICS OF TEMPERATURE.

By Diagram No. 10, it may be seen that in the City of London during thirty years the fluctuations in the number of deaths from phthisis followed the fluctuations of temperature, nearly as constantly as a shadow, rising and falling, not with but after the temperature changes. In the month of September (following the most favorable temperature in July) the deaths reach the lowest point—an average of 232.4 per week. If the temperature had continued thus favorable throughout the period, it is reasonable to believe that the deaths for each month would have remained the same—an average of 232.4 per week, or 6,884.8 per year, amounting to 206,544 deaths during the period of thirty years. Deducting this number from the number of deaths which really occurred, 231,036, leaves 24,492 as the number of deaths indicated to have been produced by the temperature changes shown in the diagram. Had we records of the temperature, and of the deaths from phthisis for smaller divisions of time, for each day, for instance, it seems to me probable that the fluctuations of temperature would be seen to have sustained a causal relation to a large proportion of the deaths from phthisis, even in the most favorable month. Unfortunately, such perfect records are not available. But the material was originally compiled by weeks, and during the fourth week of September the deaths were only 130, or 2.4 less than the average for that month, apparently responding to a rise of temperature which occurred eight weeks before—the usual difference of time between the fluctuations of temperature and those of the deaths. Substituting this 130 (deaths) for the 132.4 used in the above calculations, gives 28,236 deaths as due to the *weekly* fluctuations of temperature, or 3,744 more than by the *monthly* records. If dividing the unit of comparison (one month) by 4 shows 3,744 more deaths produced by the fluctuations of temperature, what would dividing by 30, or a comparison of observations by days, show? We do not know absolutely ; but by analogy we are led to believe that accurate records of the temperature and of the deaths from consumption would show that a large proportion of the *deaths* from phthisis were quantitatively related to atmospheric temperature.

Yet this relation would necessarily be obscured by the greater power possessed by some patients than by others to resist the inroads of consumption. For, on account of the varying duration of the disease, the deaths, instead of always occurring at the same interval after the exposure to the primary cause (cold and contagium), are scattered along according to the virulence of the contagium and the resisting power of the patient, thus grading down the elevations and filling up the depressions in the curve representing deaths from phthisis until it approximates a horizontal line showing only surface fluctuations corresponding with the temperature fluctuations.

The fact that the diseases of the lungs and air passages and the communicable diseases which enter by way of the air passages are later than the exposure to cold by a time equal to the average duration of the disease and the period of incubation, is shown by the diagrams which I present. Thus the maximum sickness from influenza, tonsillitis and croup is in the same month as the greatest exposure to cold, while pneumonia follows one month later, and, according to the most complete statistics, shown in Diagrams 10 and 22, the changes in the deaths from small-pox and consumption follow at a period of about two months after the temperature changes.

I believe that if the average duration of consumption was as uniform as is the average dura-

tion of small-pox, the proportion of the deaths which would be seen to be quantitatively related to the atmospheric temperature would be as great with consumption as with small-pox; and, as may be seen in Diagram No. 22, there were twice as many deaths from small-pox following the coldest season of the year as there were following the warmest season.

THE CAUSATION OF CONSUMPTION—SUMMARY.

In order that mankind shall be able to prevent or avoid the causes of consumption, it seems essential that its causation should be understood. It would seem that we are now in possession of sufficient knowledge of its causation so that, if we will but act upon that knowledge, a large proportion of the sickness and deaths from this most important of all diseases, may be prevented. What are the generalizations which supply the bases for effort for the prevention or avoidance of consumption? They seem to be about as follows:

1. Microscopic organisms called bacilli, of a species known as *bacillus tuberculosis* (Koch), accompany the disease commonly known as consumption.

2. Introduced into a *susceptible* organism, *bacillus tuberculosis* is able to reproduce, and, apparently, to cause and continue the condition known as consumption.

3. These bacilli are present in the sputa of consumptives; and, although outside the body at ordinary low temperatures they do not multiply by reproduction, they are not destroyed by drying, and, consequently, in apartments occupied by consumptives who do not take care to so dispose of the sputa that they shall not become a part of the dust of the room, the dust may contain the bacilli, or their spores. Because so large a proportion of people have consumption, the dust of halls and public places where sputa reach the floors and may become a part of the dust of the room, such dust may contain these bacilli, which are believed to be the *specific* cause of the disease.

4. The bacilli of consumption are introduced into the body in various ways; but, apparently, most frequently by way of the air-passages. (The order of the invasion of the lobes of the lungs is tolerably well understood.)

5. Statistics of sickness, and of deaths, collated with meteorological statistics, seem to prove that the consumptive processes go on most actively after times of low atmospheric temperature, and least actively after times of high atmospheric temperature. It would seem that atmospheric temperature is, directly or indirectly, a *controlling* cause of consumption.

6. Statistics of sickness and of death from consumption, collated with statistics of sickness and deaths from other diseases, prove that, in the long average, consumption is somewhat uniformly preceded in time and place (and inferentially in the same individual, by one of these diseases), by the irritative and exudative diseases of the lungs and air-passages, such diseases as influenza, tonsillitis, croup, bronchitis and pneumonia generally preceding, in the same locality, the occurrence of recognized consumption; they are, apparently, conditions antecedent to consumption.

7. Statistics of sickness and of deaths, collated with meteorological statistics (Seibert, Baker), prove that the irritative and exudative diseases of the lungs and air-passages follow uniformly and quantitatively, in their rise and fall, the fall and rise of the atmospheric temperature, indicating that, directly or indirectly, atmospheric temperature is a *controlling* cause of those diseases.

8. The accumulation of non-volatile salts (chlorides) in the sputa and solidified lung in pneumonia (Beale), coupled with the fact of the disappearance of the chlorides from the urine during the onward progress of pneumonia (Redtenbacher), collated with statistics of sickness, of deaths and of meteorological conditions, and with certain facts in physiology (Brücke and Hoppe), pathology (Stokvis), and chemistry, seem to prove that the control which atmospheric temperature has of pneumonia (and, if of pneumomonia, also its control of all those irritative and exudative diseases of the lungs and air-passages, which it does control), is not direct, but indirect through its well-known control of the atmospheric humidity, and so of the quantity of water exhaled from the lungs and air-passages, influencing the quantity of non-volatile salts which may there accumulate.

9. Residence in low, wet localities tends toward the causation of consumption, and toward the fatality of the disease (Bowditch, Buchanan, Pepper, Trudeau), because in all such localities the atmosphere is cold, and consequently its absolute humidity is small. Other concomitant conditions may contribute — greater atmospheric pressure, greater daily range of pressure, greater daily range of temperature, more active oxidation, less tendency toward deoxidation than occurs under free exposure to sunlight, lack of sufficient nourishing food, etc.

10. Among causes known, or believed, to be *predisposing* to consumption, are: heredity; temperament (certain types of auburn-haired persons being supposed to be especially liable to consumption); narrow lymph-spaces in the connective tissue (Formad),[33] possibly because of their more readily clogging up by saline, albuminous or fibrinous exudations; and excess of such non-volatile salts as sodium chloride in the food or drink.

THE PREVENTION OF CONSUMPTION.

We come now to the most important utilitarian

[33] Jour. of Am. Med. Ass'n, Vol. 2, p. 148.

question connected with this subject,—What can be done to lessen the ravages of this most destructive disease?

It is gratifying to be able to say that, if we accept the evidence collected in this essay, much can be done; and that there is promise of the prevention of a very large proportion of the sickness and of the deaths from consumption, through the adoption of measures which are not difficult, yet which require, for their most speedy and complete accomplishment, such an amount of coöperation by all classes of people as can only be secured through the faithful labors of intelligent boards of health, or of some agency for the thorough dissemination of the truth respecting this disease and the means for its avoidance, restriction, prevention, and climatic and other treatment. It is still true as written in the Bible—"My people are destroyed for lack of knowledge."[34] When once the people know, fully, how and why consumption is caused, they will find and adopt rational methods of protection from that disease.

PREVENTIVE MEASURES.

1. Having in mind the foregoing generalizations, numbered 1, 2, 3, 4, relative to the supposed *specific* cause of consumption, it would seem to be practicable to so enforce, upon the minds of the people generally, the importance of the destruction or the disinfection of all sputa from consumptives, that the present very general distribution[35] of those microörganisms shall be very greatly lessened.

The consumptive might carry small pieces of cloth, each just large enough to properly receive one sputum, and paper envelopes or wrappers in which the cloth may be put as soon as once used, and with its envelope burned on the first opportunity.

2. What has been said about the destruction or disinfection of the sputa of consumptives should apply also to the dejecta; because it has been shown (by Friedländer[36]) that the bacilli are to be found in the urine of persons with tubercular disease of the urinary organs, and in the fæces of those with tubercular disease of the bowels, and they may be in the fæces of those who swallow sputa containing the bacilli, that is, possibly, of any consumptive.

Through better systems of ventilation, much may be done for the lessening the number of microörganisms inhaled with the dust of floors, carpets, etc.; especially by having the foul air exits at the floor-level, so that the general motion of the foul air shall be downwards, and not upwards into the nostrils of the inmates of the room. A more liberal supply of fresh air to all occupied apartments, especially public rooms, would lessen the danger of inhaling air which has already been breathed, and also of microörganisms, etc. So long as the specific cause of consumption is so widespread, lives may probably be saved by the use of respirators by those who sweep and dust rooms which consumptives have occupied.

3. Generalizations Nos. 5 and 7 make it important that consumptives, and persons susceptible to consumption, should especially guard against the inhalation of cold air. It enforces the importance of having such persons spend the winters in a climate warmer than that to which they have been accustomed.

4. Generalization No. 6, in connection with Nos. 1, 2, 3 and 4, teaches us that it is important that every person suffering from one of the irritative or exudative diseases of the lungs or air-passages, should be especially protected from the inhalation of the bacillus tuberculosis.

5. Generalization No. 8 enforces the importance of supplying moisture to all air which requires to be warmed, in hospitals, houses, public buildings, and wherever the temperature of the air can be controlled.

6. Generalizations Nos. 8 and 10 teach us that it may be of very great importance to see that our food and drink, especially in winter, shall not contain an excess of chloride of sodium or other non-volatile salt liable to be exuded into the air-cells or air-passages, and left there by unusual evaporation of vapor through the inhalation of cold air, which is necessarily dry, or of air which has been warmed without the addition of moisture.

6. Generalization No. 9 has been previously commented on, and some of the advice based upon it by Dr. Bowditch has been quoted. But his results have been so well upheld by Drs. Buchanan and Pepper, and by the experiments of Dr. Trudeau, that since we now think we know the reason why residence over low, wet soil endangers health and life from consumption, there should be no hesitation in acting in accordance with the laws laid down by Dr. Bowditch, relative to the avoidance of residence over low, wet soil, and in any cellar-like place.

8. In addition to what is generally known for the prevention of small-pox, diphtheria and scarlet fever, the facts incidentally set forth in this essay teach why it is that the inhalation of cold, dry air is an important factor in the causation of those diseases, and why it is even more important in winter than in summer to guard people from them.

9. Finally, there is given herein evidence as to the causation of a large class of ordinary diseases (of the lungs and air-passages), which should lead to the prevention of a very considerable proportion of the sickness and deaths therefrom.

That there shall be a very thorough dissemi-

34 Hosea, Chapter IV, verse 6.

35 Dr. James E. Reeves, ex-Pres. of the Am. Public Health Association, demonstrated the presence of innumerable tubercle bacilli in a sputum on the sidewalk, near the post office in Wheeling, W. Va. They are probably to be found on the sidewalk in every city.

36 Manual of Microscopical Technology, pp. 219, 236, 237.

nation of the truth, or at least of the nearest approach to the truth that is now known, respecting these subjects which are of vital consequence to every man, woman and child, and that, through the attention to such subjects which shall result from such thorough dissemination, many valuable lives may be saved, and much suffering and sorrow may be prevented, is the earnest wish of the author of this essay.

CROUP AND TEMPERATURE IN MASSACHUSETTS.

TABLE 1.—Exhibiting by months reduced to uniform length—30 days each—the number of *deaths* from *croup* in *Massachusetts* during 23 years, 1863-85, in comparison with the average *atmospheric temperature* for 48 years[1] (1790—1870) at Cambridge, Mass. Deaths computed from the 44th Registration Report of Massachusetts, 1886; and the temperature is taken from the Smithsonian tables, "Distribution and Variations of Atmospheric Temperature," 1876, p. 40.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Deaths.[2]	1,469	1,290	1,181	1,023	774	559	427	435	729	1,239	1,649[3]	1,631
Av. temperature.	25.25	26.28	34.39	44.40	56.01	66.74	71.86	69.82	61.89	50.18	39.28	29.34

[1] The series is stated as follows: "Begins Jan. 1790; ends Dec. 1870; extent, 48 years and 6 months." Some of the years between 1790 and 1870 were omitted. This series is used because it is the longest available, and, therefore, most likely to give the correct "normal" curve. That it does supply a correct "norm," and that, in table 2 and diagram No. 2, the normal curve representing absolute humidity is shown, is made evident by a comparison of the curve for temperature in diagram No. 1 with the curve for absolute humidity in diagram No. 2, noting how closely the two curves resemble each other, and considering how completely the absolute humidity of the atmosphere is controlled by the atmospheric temperature. The two curves are so nearly alike that it has been thought not necessary to make any more diagrams exhibiting the absolute humidity in Massachusetts, but to let the curve representing the temperature—the controlling condition—stand also as representing the absolute humidity.

[2] Total deaths from croup in the 23 years, distributed by months.

[3] To the author of this essay it seems probable that some proportion of the deaths recorded as from croup were from diphtheritic croup, and also that some part of the rise in the autumn, after the opening of the schools, may be due to the spreading of that communicable disease.

CROUP AND ABSOLUTE HUMIDITY IN MASSACHUSETTS.

TABLE 2.—Exhibiting by months reduced to uniform length—30 days each—the number of *deaths* from *croup* in Massachusetts during 23 years, 1863-85, in comparison with the *average absolute humidity* of the atmosphere at Boston during 17 years, 1870-86, computed from the tables on *relative* humidity and *temperature*, in the Report of the Chief Signal Officer, U. S. A., for 1886.[4]

	Jan.	Feb.	Mar.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.
Deaths[5]	1,469	1,290	1,181	1,023	774	559	427	435	729	1,239	1,649	1,631
Abs. Humidity. .	1.39	1.45	1.87	2.32	3.37	4.81	5.78	5.66	4.56	3.19	2.19	1.59

[4] That this supplies satisfactory data concerning the absolute humidity of the atmosphere in that vicinity is made probable by the steadiness of the curve, as may be seen in diagram No. 2, and especially by a comparison of that curve with the one representing the atmospheric temperature at Cambridge, Mass., in diagram No. 1.

[5] Total deaths from croup in the 23 years, distributed by months.

CONSUMPTION AND TEMPERATURE IN MASSACHUSETTS.

TABLE 3.—Exhibiting by months reduced to uniform length—30 days each—the number of *deaths* from *consumption* in Massachusetts during 23 years, 1863-85, in comparison with the *average atmospheric temperature* for 48[6] years (1790—1870) at Cambridge, Mass. (Deaths computed from the 44th Registration Report of Mass., 1886; and the temperature is taken from the Smithsonian tables, "Distribution and Variations of Atmospheric Temperature, 1876," p. 40.)

	Jan.	Feb.	Mar.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.
Deaths[7]	9,888	10,261	10,723	10,658	10,390	9,223	9,273	9,773	9,875	9,606	9,590	9,607
Av. Temperature.	25.25	26.28	34.39	44.40	56.01	66.74	71.86	69.82	61.89	50.18	39.28	29.34

[6] The series is stated as follows: "Begins Jan., 1790; ends Dec., 1870; extent, 48 years and 6 months." Some of the years between 1790 and 1870 were omitted. This series is used because it is the longest available, and, therefore, most likely to give the correct normal curve.

[7] Total deaths from consumption in the 23 years, distributed by months.

SMALL-POX AND TEMPERATURE IN MASSACHUSETTS.

TABLE 4.—Exhibiting by months reduced to uniform length—30 days each—the number of *deaths* from *small-pox* in Massachusetts during 23 years, 1863-85, in comparison with the average *atmospheric temperature* for 48 years[8] (1790-1870) at Cambridge, Mass. Deaths computed from the 44th Registration Report of Massachusetts, 1886; and the temperature is taken from the Smithsonian Tables, "Distribution and Variations of Atmospheric Temperature," 1876, p. 40.

	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.
Deaths[9]	458	314	269	270	295	202	177	111	152	214	311	489
Av. Temperature.	25.25	26.28	34.39	44.40	56.01	66.74	71.86	69.82	61.89	50.18	39.28	29.34

[8] The series is stated as follows: "Begins Jan., 1790, ends Dec., 1870; extent, 48 years and 6 months." Some of the years between 1790 and 1870 were omitted. This series is used because it is the longest available, and therefore most likely to give the correct normal curve.

[9] Total deaths from small-pox in 23 years, distributed by months.

DIPHTHERIA AND TEMPERATURE IN MASSACHUSETTS.

TABLE 5.—Exhibiting by months reduced to uniform length—30 days each—the number of *deaths* from *diphtheria* in Massachusetts during 23 years, 1863-85, in comparison with the *average atmospheric temperature* for 48 years[10] (1790-1870), at Cambridge, Mass. (Deaths computed from the 44th Registration Report of Mass., 1886; and the temperature is taken from the Smithsonian Tables, "Distribution, and Variations of Atmospheric Temperature, 1876," p. 40.)

	Jan.	Feb,	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.
Deaths[11]	2,527	2,174	1,825	1,736	1,643	1,588	1,365	1,284	1,818	2,598	2,712	2,687
Av. Temperature.	25.25	26-28	34.39	44.40	56.01	66.74	71.86	69.82	61.89	50.18	39.28	29.34

[10] The series is stated as follows: "Begins Jan., 1790; ends Dec., 1870; extent, 48 years and 6 months." Some of the years between 1790 and 1870 were omitted. This series is used because it is the longest available, and therefore most likely to give the correct normal curve.

NOTE.—The opening of Schools in the autumn may have to do with the increase culminating in November.

[11] Total deaths from diphtheria, in 23 years, distributed by months.

PNEUMONIA AND TEMPERATURE IN MASSACHUSETTS.

TABLE 6.—Exhibiting by months reduced to uniform length—30 days each—the number of *deaths* from *pneumonia* in Massachusetts during 23 years, 1863-85, in comparison with the *average atmospheric temperature* for 48 years[12] (1790-1870), at Cambridge, Mass. (Deaths computed from the 44th Registration Reports of Mass., 1886; and the temperature is taken from the Smithsonian Tables, "Distribution, and Variations of Atmospheric Temperature, 1876," p. 40.)

	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.
Deaths[13]	6,048	6,791	7,042	6,508	4,967	2,776	1,828	1,514	1,913	2,767	4,125	5,221
Av. Temperature.	25.25	26.28	34.39	44.40	56.01	66.74	71.86	69.82	61.89	50.18	39.28	29.34

[12] The series is stated as follows: "Begins Jan., 1790; ends Dec., 1870; extent, 48 years and 6 months." Some of the years between 1790 and 1870 are omitted. This series is used because it is the longest available, and therefore most likely to give the correct normal curve.

[13] Total deaths from pneumonia, in the 23 years, distributed by months.

SCARLATINA AND TEMPERATURE IN MASSACHUSETTS.

TABLE 7.—Exhibiting by months reduced to uniform length—30 days each—the number of *deaths* from *scarlatina* in Massachusetts during 23 years, 1863-85, in comparison with the *average atmospheric temperature* for 48 years[14] (1790-1870), at Cambridge, Mass. (Deaths computed from the 44th Registration Report of Mass., 1866; and the temperature is taken from the Smithsonian Tables, "Distribution, and Variations of Atmospheric Temperature, 1876," p. 40.)

	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.
Deaths[15]	2,340	2,253	2,313	2,209	2,017	1,655	1,224	1,026	953	1,247	1,704	1,964
Av. Temperature.	25.25	26.28	34.39	44.40	56.01	66.74	71.86	69.82	61.89	50.18	39.28	29.34

[14] The series is stated as follows: "Begins Jan., 1790; ends Dec., 1870; extent, 48 years and 6 months." Some of the years between 1790 and 1870 were omitted. This series is used because it is the longest available, and therefore most likely to give the correct normal curve.

[15] Total deaths from Scarlatina, in 23 years, distributed by months.

TEMPERATURE AND SICKNESS FROM PNEUMONIA IN U. S. ARMIES.

TABLE 8.—Exhibiting by months for a series of years the average atmospheric temperature at six stations representing approximately the latitude and longitude of the Aggregate forces of the Armies of the United States in the war of the Rebellion, in comparison with the average number of cases of *sickness* from *pneumonia* per 10,000 ("mean strength") of those forces, by months (of uniform length) during the four years, 1862-65.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Cases per 1,000 of Mean Strength	38.1	41.7	38.1	28.4	15.9	10.5	8.1	7.2	7.7	14.1	23.8	29.1
Average Atmospheric Temperature. . .	36	38	45	54	66	74	78	76	69	56	46	38

SICKNESS FROM CONSUMPTION IN WHITE TROOPS, U. S. ARMY, AND TEMPERATURE.

TABLE 9.—Exhibiting, by months reduced to uniform length—30 days each—for the four years, 1862-65, the average number of *cases* of *consumption* per 10,000 soldiers ("mean strength") of the white troops of the U. S. Army in the war of the Rebellion, in comparison with the *average atmospheric temperature* at six stations representing approximately the latitude and longitude of the aggregate forces of the Armies of the United States.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Aver. cases per 10,000 of Mean Strength	5.63	5.95	5.92	5.08	4.33	4.52	4.69	4.59	4.02	4.26	4.47	4.31
Average Temperature at Six Stations. .	31	38	45	54	66	74	78	76	69	56	46	38

TEMPERATURE, AND DEATHS FROM PHTHISIS IN LONDON, ENGLAND.

TABLE 10.—Exhibiting, by months, for a period of thirty years, 1845–1874, the relation of average deaths per week in London, England, from Phthisis, to the average atmospheric temperature for the same period of time. This table is graphically represented in Diagram 10.

Thirty Years, 1845–1874.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. deaths per week from phthisis . . .	154	153.25	160.2	162	157.25	150	144.75	136.50	132.4	135.75	146	147
Av. temperature, degrees Fahr	38.6	40.1	40.2	48.6	52.7	60.0	64.2	63.5	59.1	52.2	44.2	40.5

TEMPERATURE, AND SICKNESS FROM CONSUMPTION IN MICHIGAN.

TABLE 11.—Exhibiting, by months, for a period of nine years, 1878–1886, the relation between sickness in Michigan from consumption, and the average atmospheric temperature for the same period of time. This table is graphically represented in Diagram 11.

Nine Years, 1878–1886.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. percentage of reports of sickness . .	65	68	69	70	67	65	63	61	62	64	64	63
Av. temperature, degrees Fahr	20.72	22.68	30.23	44.06	55.84	64.83	70.27	67.88	61.43	35.87	35.87	25.47

TEMPERATURE, AND DEATHS FROM BRONCHITIS IN LONDON.

TABLE 12.—Exhibiting, by months, for a period of thirty years, 1845–1874, the relation of average deaths per week in London, England, from bronchitis, to the average atmospheric temperature for the same period of time. This table is graphically represented in Diagram 12.

Thirty Years, 1845–1874.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. deaths per week from bronchitis . .	193.5	172.5	165	127.5	90.0	63.2	48.25	41.0	48.2	76.5	141.25	190.2
Av. temperature, degrees Fahr	38.6	40.1	42.2	48.6	52.7	60.0	64.2	63.5	59.1	52.2	44.22	40.5

TEMPERATURE, AND SICKNESS FROM CROUP IN MICHIGAN.

TABLE 13.—Exhibiting, by months, for a period of ten years, 1877–1886, the relation between sickness in Michigan from membranous croup and the average atmospheric temperature for the same period of time. This table is graphically represented in Diagram 13.

Ten Years, 1877–1886.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. percentage of reports of sickness . .	[illegible]	10	8	7	5	4	2	3	4	6	9	10
Av. temperature, degrees Fahr	20.56	23.62	29.80	44.33	56.08	65.10	70.52	68.14	61.67	50.83	36.04	26.60

TEMPERATURE, AND SICKNESS FROM "RESPIRATORY DISEASES" IN INDIA.

TABLE 14.—Exhibiting, by months, for a period of three years, 1883–1885, the relation of sickness from "respiratory diseases" among the native troops in India to the average atmospheric temperature for the same period of time. This table is graphically represented in Diagram 14.

Three Years, 1883–1885.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. cases of sickness per 1,000 soldiers .	102.8	71.6	51.8	38.6	33.8	26.6	25.5	23.7	31.8	37.7	59.9	93.8
Av. temperature, degrees Fahr	68.7	70.6	79.1	83.9	85.2	84.8	83.3	82.7	82.3	80.5	74.2	69.1

TEMPERATURE, AND SICKNESS FROM INFLUENZA IN MICHIGAN.

TABLE 15.—Exhibiting, by months, for the ten years, 1877–1886, the average percentage of reports stating the presence of sickness from influenza in Michigan, also the average atmospheric temperature at stations in Michigan for the same period of time. This table is graphically represented in Diagram 15.

Ten Years, 1877-1886.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. percentage of reports of sickness. .	55	61	59	52	38	28	20	21	29	33	41	48
Av. temperature, degrees Fahr	20.56	23.62	29.80	44.33	56.08	65.10	70.52	68.14	61.67	50.83	36.04	26.60

TEMPERATURE, AND SICKNESS FROM TONSILITIS IN MICHIGAN.

TABLE 16.—Exhibiting, by months, for the eight years, 1879–1886, the average percentage of reports stating the presence of sickness from tonsilitis in Michigan, also the average atmospheric temperature at stations in Michigan for the same period of time. This table is graphically represented in Diagram 16.

Eight Years, 1879–1886.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. percentage of reports of sickness. .	60	61	60	53	47	42	33	32	37	45	55	60
Av. temperature, degrees Fahr	19.91	21.77	28.82	43.04	55.98	64.79	69.78	66.25	61.11	50.68	35.56	25.82

TEMPERATURE, AND SICKNESS FROM BRONCHITIS IN MICHIGAN.

TABLE 17.—Exhibiting, by months, for the nine years, 1877–1885, the average percentage of reports stating the presence of sickness from bronchitis in Michigan, also the average atmospheric temperature at stations in Michigan for the same period of time. This table is graphically represented in Diagram 17.

Nine Years, 1877–1885.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. percentage of reports of sickness. .	77	78	77	72	61	54	43	41	49	55	67	72
Av. temperature, degrees Fahr	20.77	23.89	29.76	44.14	56.23	65.30	70.73	68.23	61.73	50.72	36.23	27.28

TEMPERATURE, AND SICKNESS FROM PNEUMONIA IN MICHIGAN.

TABLE 18.—Exhibiting, by months, for the eight years, 1877–1884, the average percentage of reports stating the presence of sickness from pneumonia in Michigan, also the average atmospheric temperature at stations in Michigan for the same period of time. This table is graphically represented in Diagram 18.

Eight Years, 1877–1884.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. percentage of reports of sickness. .	62	66	62	56	42	27	17	14	18	23	36	48
Av. temperature, degrees Fahr	21.43	25.60	31.04	44.48	56.60	65.54	70.68	68.85	62.05	51.34	35.99	27.25

ABSOLUTE ATMOSPHERIC HUMIDITY, AND SICKNESS FROM PNEUMONIA IN MICHIGAN.

TABLE 19.—Exhibiting, by months, for a period of ten years, 1877–1886, the relation of sickness in Michigan from pneumonia to the average absolute humidity. The two lines in this table are graphically represented in Diagram 19.

Ten Years, 1877–1886.	Annual Av.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Sickness from pneumonia . . .	36.5	57.9	63.1	61.1	53.9	39.3	25.1	16.1	13.3	16.7	21.3	33.4	44.8
Average absolute humidity . . .	3.44	1.38	1.51	1.81	2.75	3.91	5 27	6.07	5.84	4.98	3.71	2.30	1.73

TEMPERATURE, AND DEATHS FROM PNEUMONIA IN LONDON, ENGLAND.

TABLE 20.—Exhibiting, by months, for the thirty years, 1845–1874, the average number of deaths from pneumonia in London, England, also the average atmospheric temperature for the same period of time. This table is graphically represented in Diagram 20.

Thirty Years, 1845–1874.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. deaths per week from pneumonia .	98	86	91	82	67	53	42	37	43	66	98	108
Av. temperature, degrees Fahr	38.6	40.1	42.2	48.6	52.7	60.0	64.2	63.5	59.1	52.2	44.2	40.5

TEMPERATURE, AND SICKNESS FROM SCARLET FEVER IN MICHIGAN.

TABLE 21.—Exhibiting, by months, for a period of ten years, 1877–1886, the relation which the sickness in Michigan from scarlet fever sustained to the atmospheric temperature: Exhibiting the average atmospheric temperature, and what percentage of all weekly reports received stated that scarlet fever was under observation of the physicians who made the reports. (Over 41,000 weekly reports of sickness, and over 190,000 observations of the atmospheric temperature are represented in this table). This table is graphically represented in Diagram 21.

Ten Years, 1877–1886.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. percentage of reports	22.3	23.5	23.9	21.6	19.6	17.0	13.7	11.8	12.5	16.0	17.3	18.1
Av. temperature, degrees Fahr	20.56	23.62	29.80	44.33	56.08	65.10	70.52	68.14	61.67	50.83	36.04	26.60

TEMPERATURE, AND DEATHS FROM SMALL-POX IN LONDON, ENGLAND.

TABLE 22.—Exhibiting, by months, for thirty years, 1845–1874, the relation between the weekly average number of deaths from small-pox and the average atmospheric temperature in London, England. Records of 30,000 deaths are included in this table. This table is graphically represented in Diagram 22.

Thirty Years, 1845–1874.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. weekly number of deaths	23.00	24.00	21.60	23.75	24.50	22.40	18.00	14.25	13.00	13.00	14.50	18.20
Av. temperature, degrees Fahr	38.6	40.1	42.2	48.6	52.7	60.0	64.2	63.5	59.1	52.2	44.2	40.5

DEATHS FROM CONSUMPTION IN WHITE TROOPS, U. S. ARMY, AND TEMPERATURE.

TABLE 23.—Exhibiting, by months reduced to uniform length—30 days each—for the four years, 1862-65, the average number of *deaths* from *consumption* per 100,000 soldiers ("mean strength") of the white troops of the U. S. Army in the war of the Rebellion in comparison with the *average atmospheric temperature* at six stations representing approximately the latitude and longitude of the aggregate forces of the Armies of the United States.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Av. No. of Deaths per 100,000 of M. Str.	19.55	22.47	24.23	19.63	17.00	16.07	17.38	15.75	14.96	17.62	17.13	18.06
Av. Temperature at Six Stations.	36	38	45	54	66	74	78	76	69	56	46	38

SICKNESS FROM DIPHTHERIA IN MICHIGAN, AND TEMPERATURE.

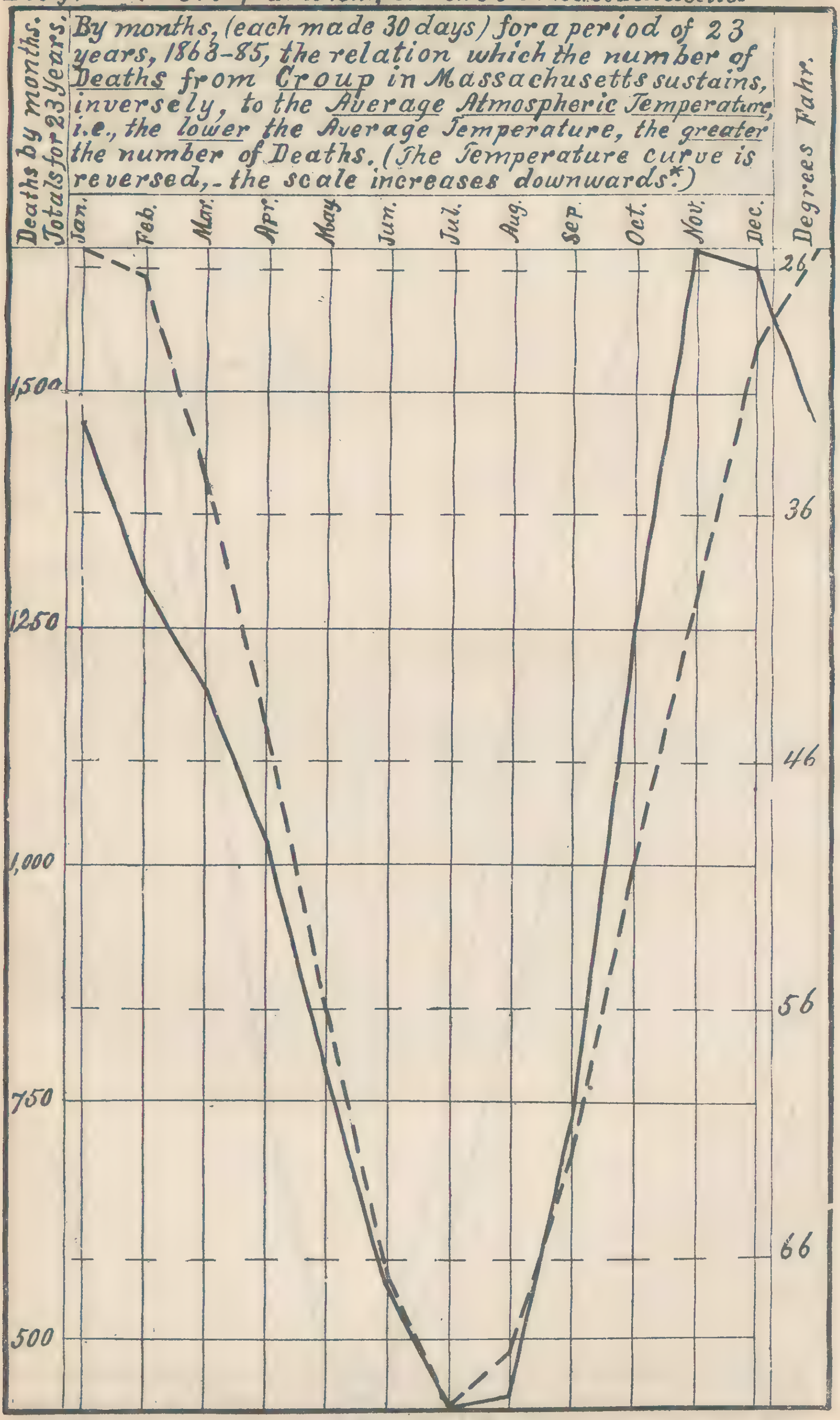
TABLE 24.—Exhibiting by months for a period of nine years, 1877-85, the relation of *sickness* in Michigan from *diphtheria* to the *average atmospheric temperature.*

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Per cent. of Weekly Reports.	29	25	22	21	18	16	15	16	19	27 [16]	30 [16]	29
Average Temperature.	20.77	23.89	29.76	44.14	56.23	65 30	70.73	68.23	61.73	50.72	36.23	27.28

[16] It would seem possible that this sudden great increase of sickness from diphtheria may, in part, be due to the spreading of the disease incident to the opening of schools in the autumn.

NOTE.—Data for this table and the diagram illustrating it are found in Exhibit XIII, p. 122; and in the upper line of Exhibit V, p. 24, Annual Report of the Michigan State Board of Health, for 1886.

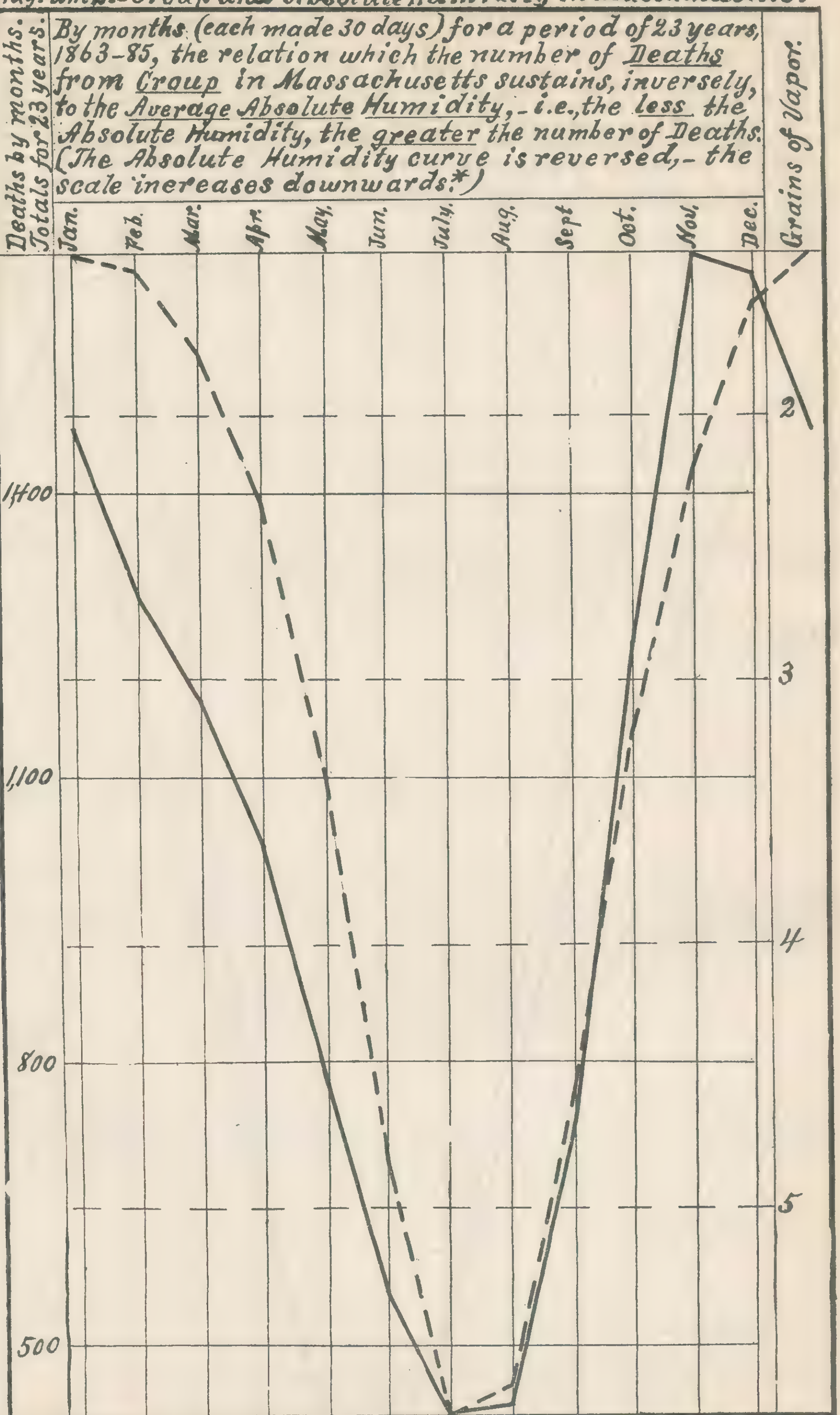
Diagram 1.– Croup and Temperature in Massachusetts.



Deaths ————. Average Temperature — — —.

* The numbers of deaths are compiled from the 44th Registration Report of Mass., 1886. The Average Temperature is compiled from a table on page 40 of the Smithsonian Tables "Distribution and Variations of the Atmospheric Temperature". It is for a period of 48 years, between 1790–1870 at Cambridge, Mass.

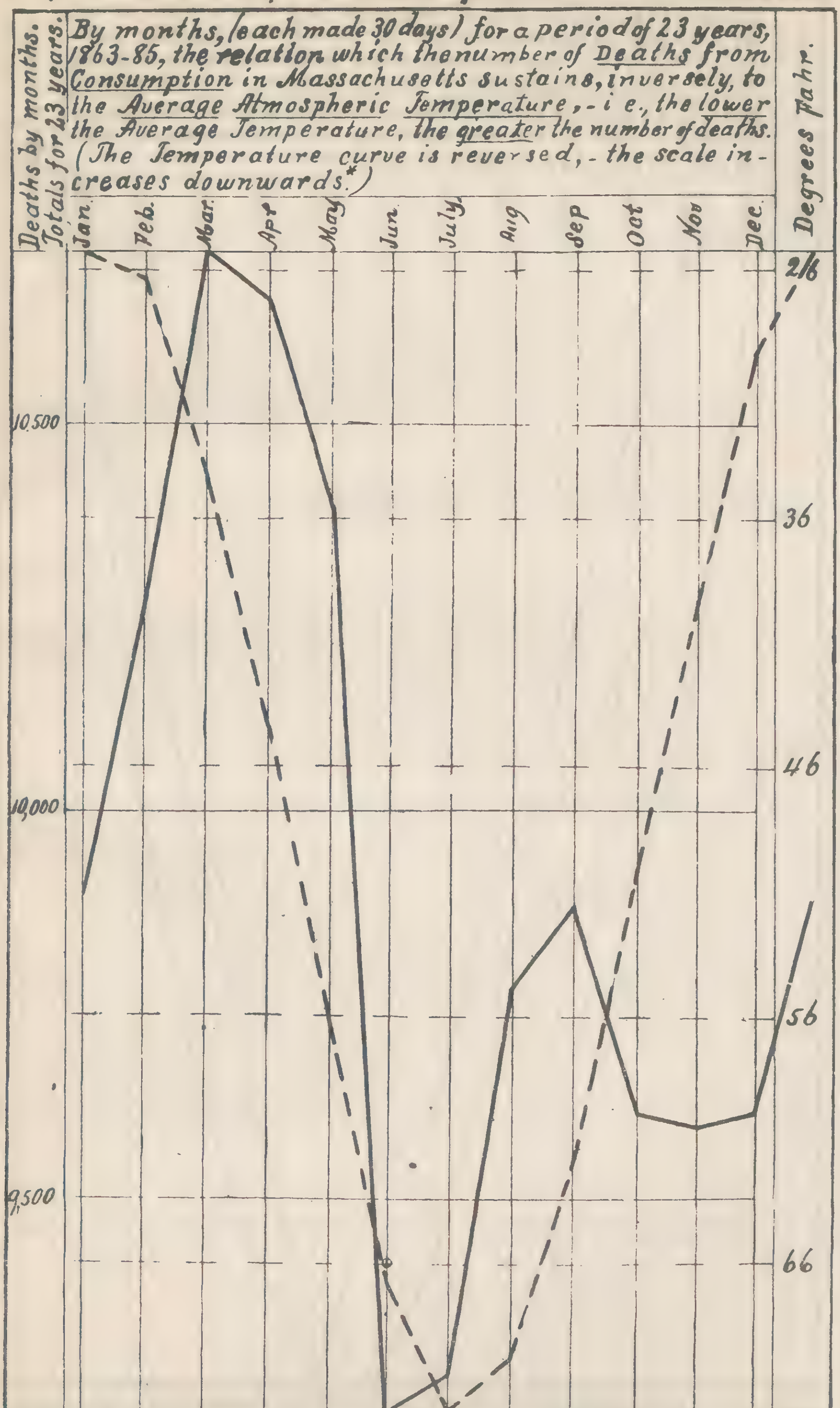
Diagram 2.—Croup and Absolute Humidity in Massachusetts.



Deaths ————. Average Absolute Humidity — — —.

*The numbers of deaths are compiled from the 44th Registration Report of Mass., 1886. The Average Absolute Humidity is compiled from the Relative Humidity and Temperature in the Report of the Chief U.S. Signal Officer for 1886. The curve represents the normal, at Boston, for 17 years, 1870-86.

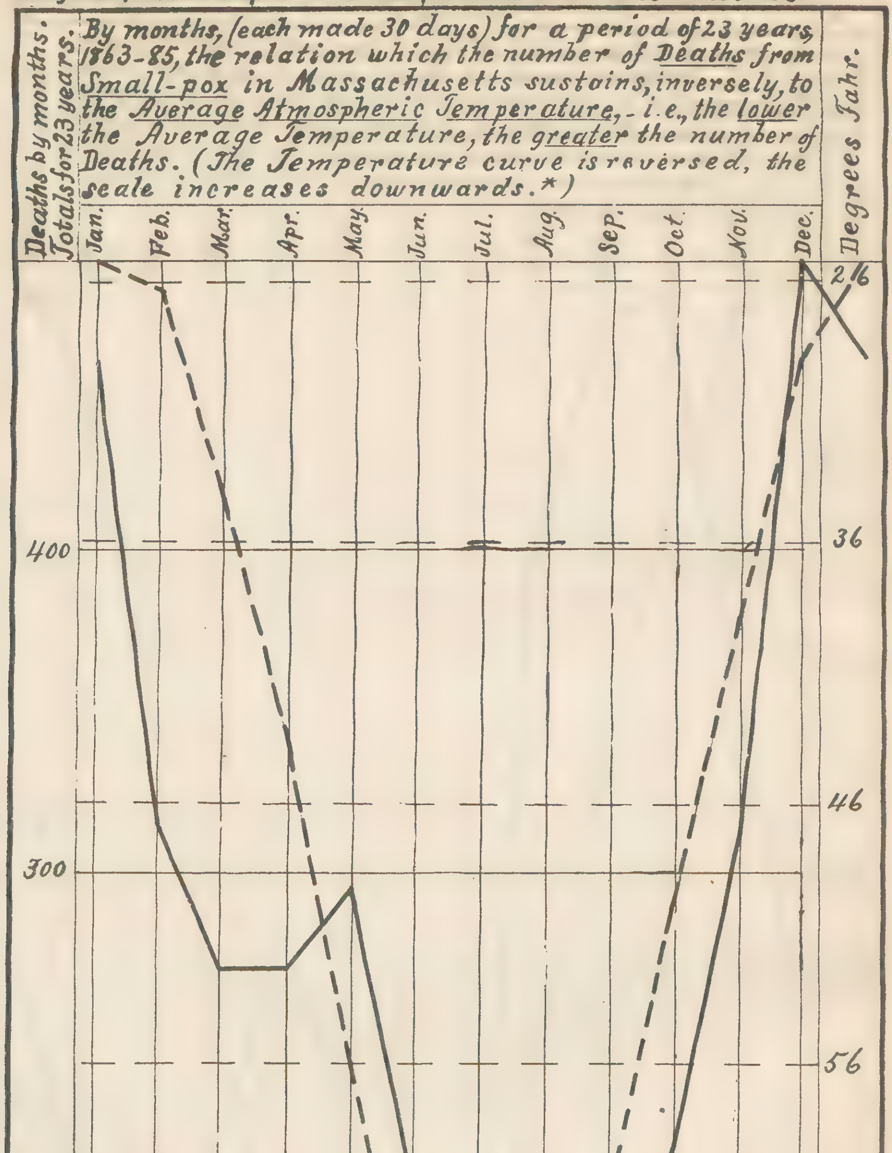
Diagram 3.- Consumption and Temperature in Massachsetts.



Deaths ———————. Average Temperature — — — — — — —.

*The numbers of deaths are compiled from the 44th Registration Report of Mass., 1886. The Average Temperature is compiled from a table on page 40 of the Smithsonian Tables "Distribution and Variations of the Atmospheric Temperature" It is for a period of 48 years between 1790-1870 at Cambridge Mass.

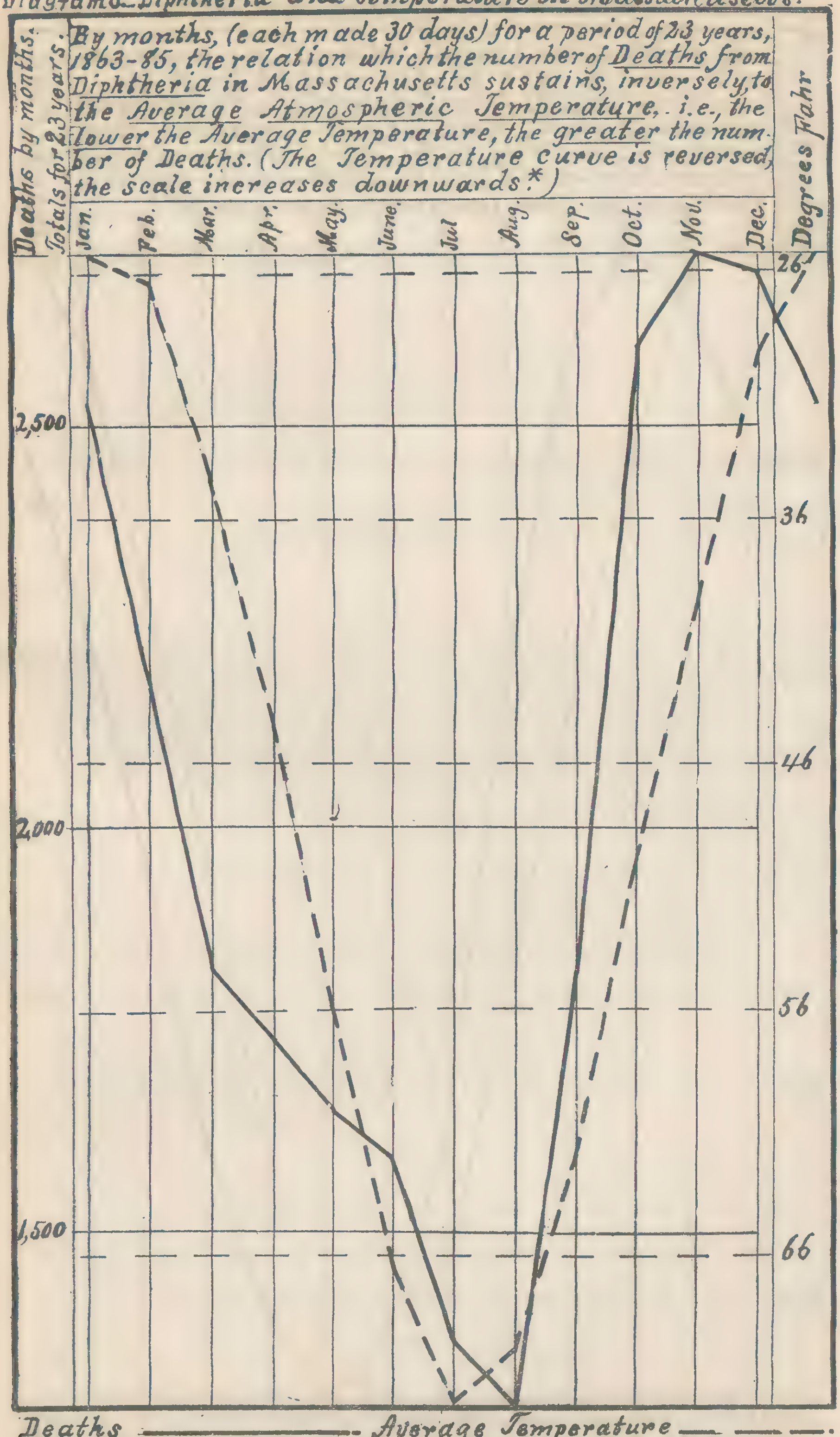
Diagram 4.- Small-pox and Temperature in Massachusetts.



Deaths ———————. Average Temperature — — —.

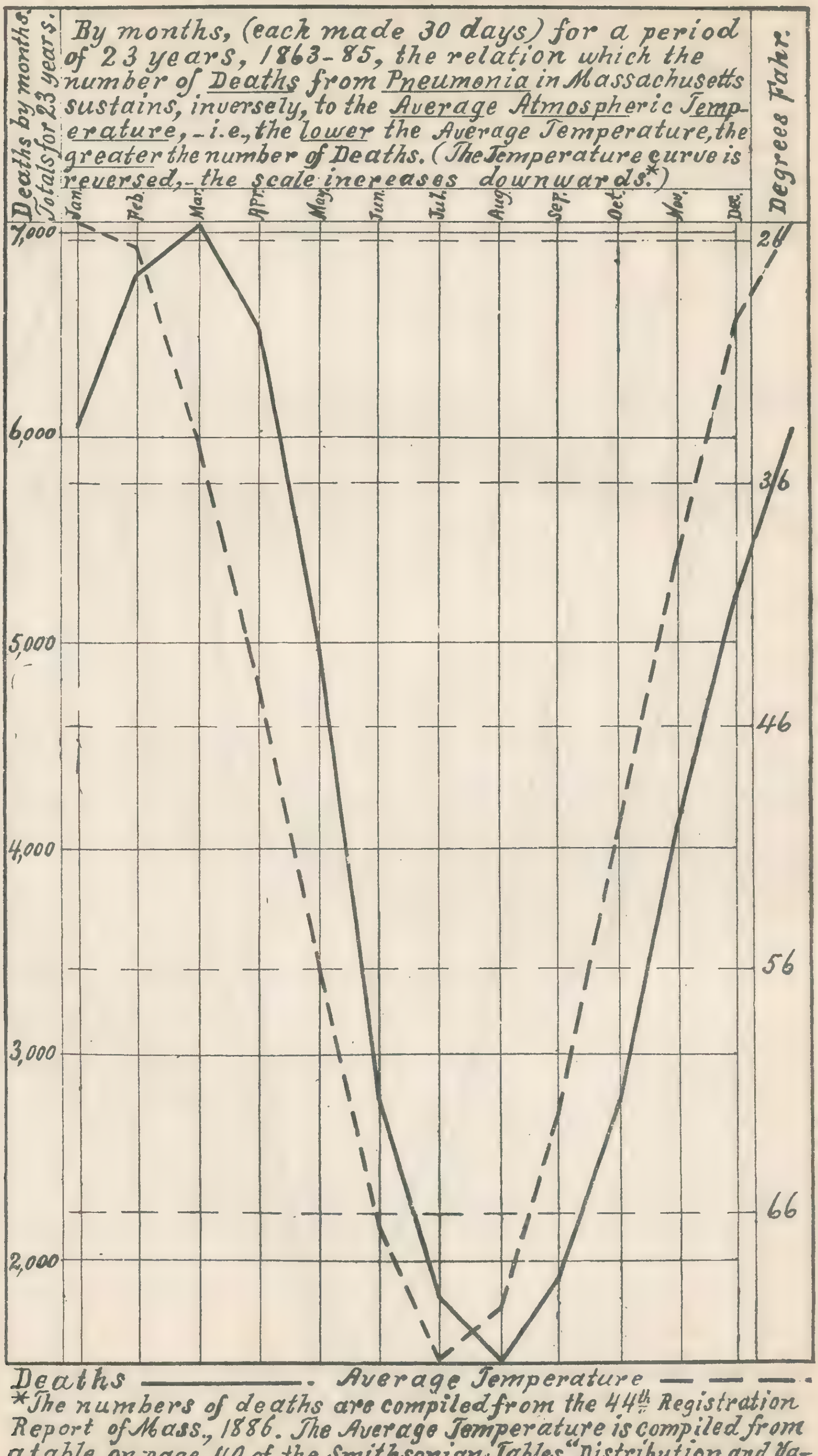
*The numbers of deaths are compiled from the 44th Registration Report of Mass., 1886. The Average Temperature is compiled from a table on page 40 of the Smithsonian Tables "Distribution and Variations of the Atmospheric Temperature." It is for a period of 48 years between 1790-1870, at Cambridge, Mass.

Diagram 5. Diphtheria and Temperature in Massachusetts.



*The numbers of deaths are compiled from the 44th Registration Report of Mass., 1886. The Average Temperature is compiled from a table on page 40 of the Smithsonian Tables "Distribution and Variations of the Atmospheric Temperature." It is for a period of 48 years, between 1790-1870 at Cambridge, Mass.

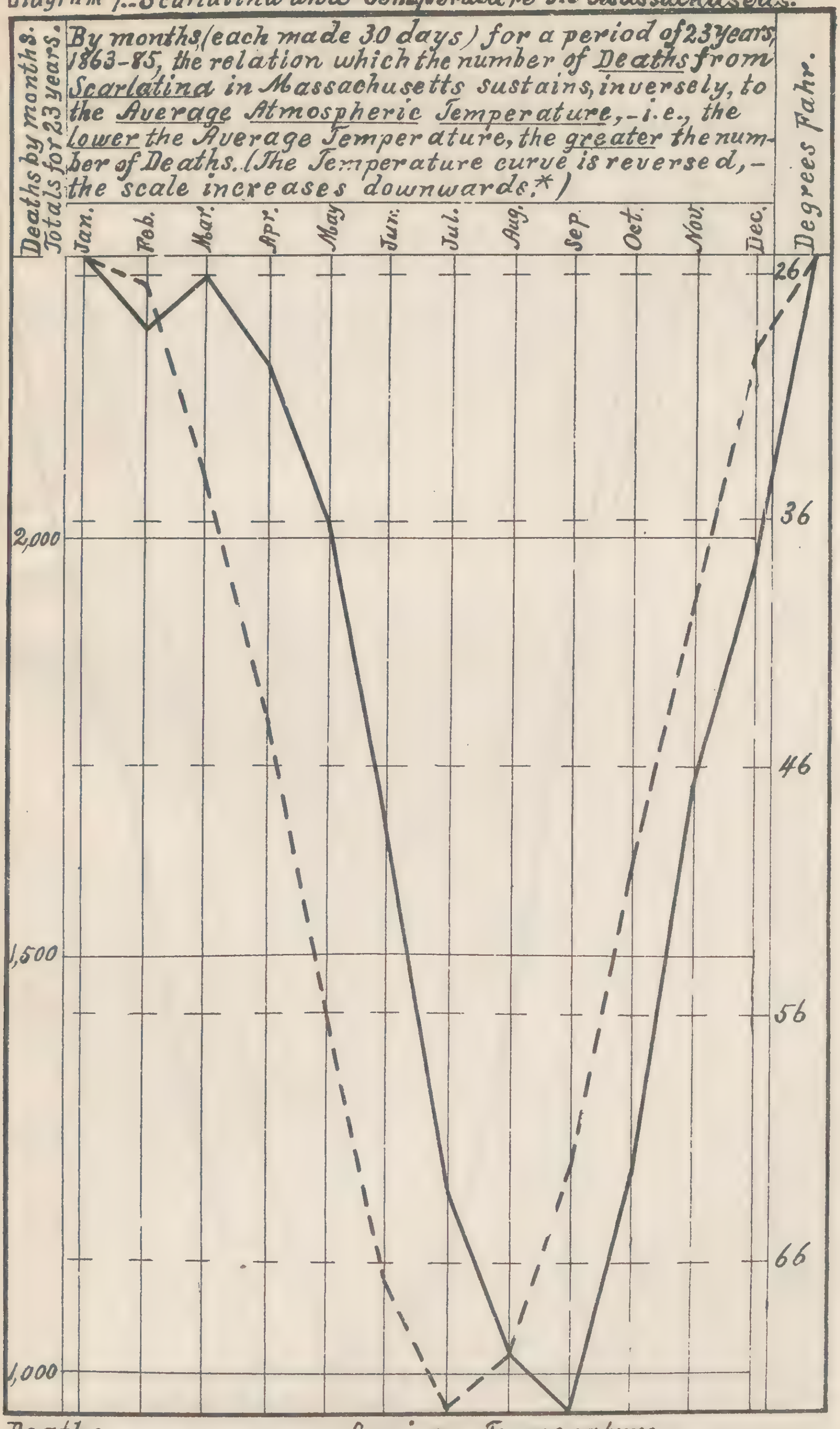
Diagram 6.-Pneumonia and Temperature in Massachusetts.



Deaths ———. Average Temperature — — —.

*The numbers of deaths are compiled from the 44th Registration Report of Mass., 1886. The Average Temperature is compiled from a table on page 40 of the Smithsonian Tables "Distribution and Variations of the Atmospheric Temperature." It is for a period of 48 years between 1790-1870, at Cambridge, Mass.

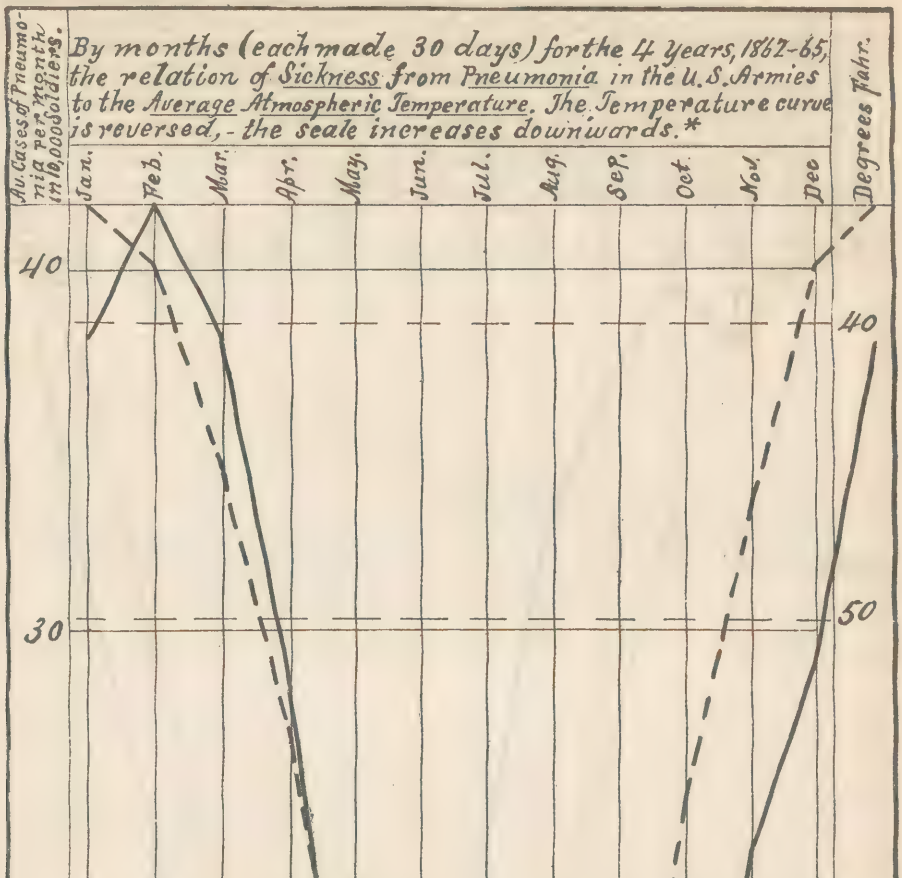
Diagram 7.-Scarlatina and Temperature in Massachusetts.



Deaths ——————— Average Temperature — — — —

*The numbers of deaths are compiled from the 44th Registration Report of Mass., 1886. The Average Temperature is compiled from a table on page 40 of the Smithsonian Tables "Distribution and Variations of the Atmospheric Temperature." It is for a period of 48 years between 1790-1870, at Cambridge, Mass.

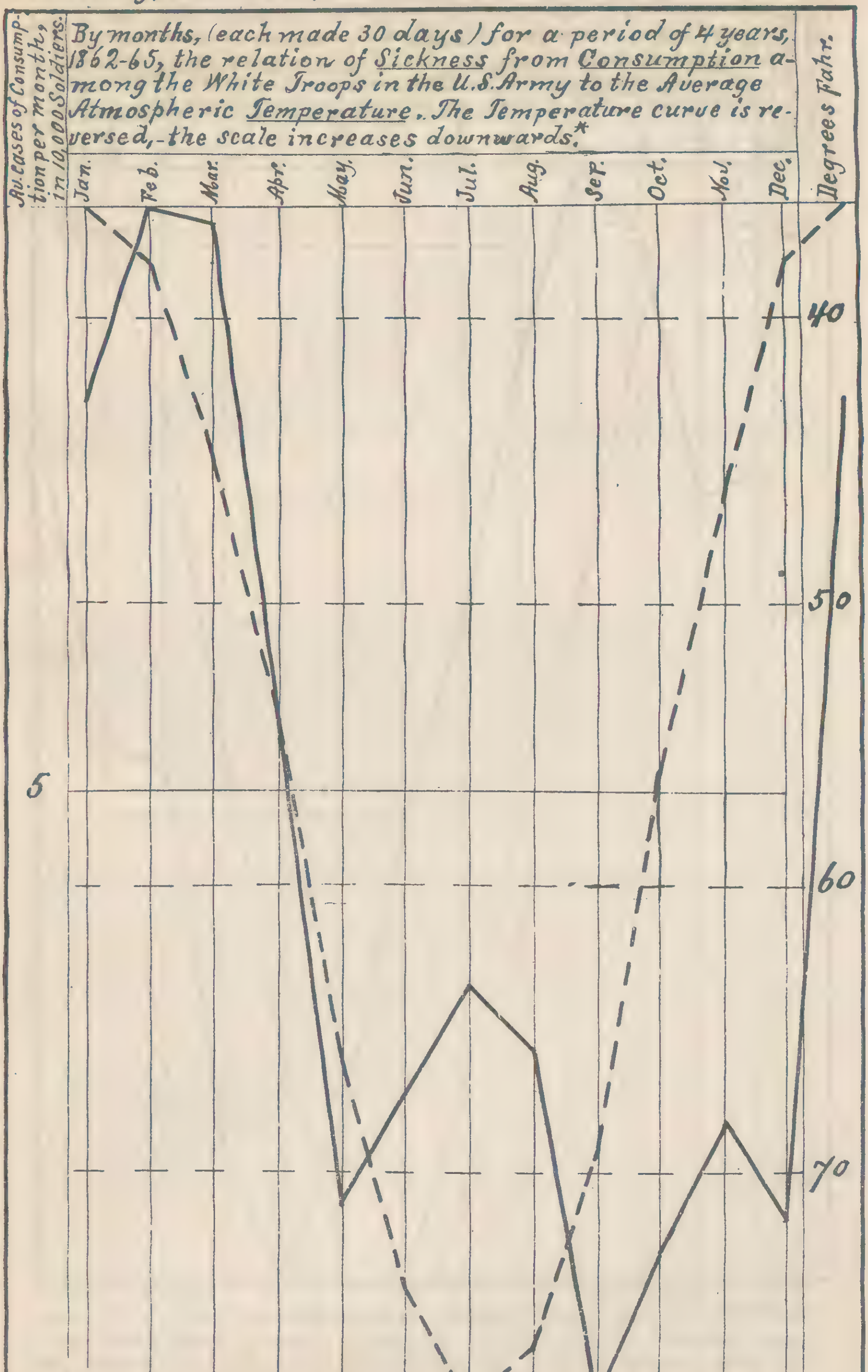
Diagram 8.–Temperature, and Sickness from Pneumonia in U.S. Armies.



Pneumonia ——————. Average Temperature — — —

*The temperature curve is made from the normals at six stations representing approximately the localities occupied by the armies of the United States, during the war of the rebellion.

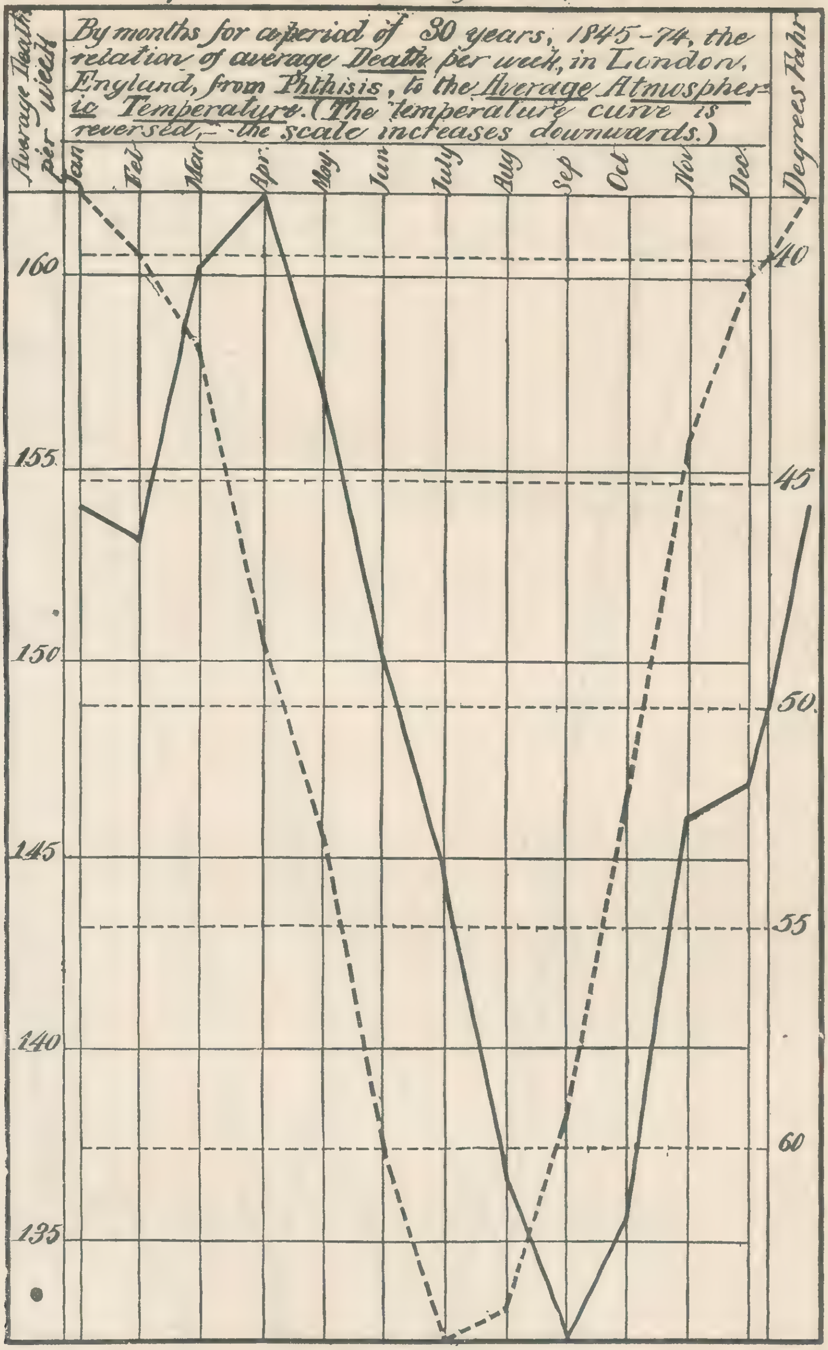
Diagram 9.–Sickness from Consumption in White Troops, U.S. Army, and Temperature



Sickness ———————. Average Temperature — — —

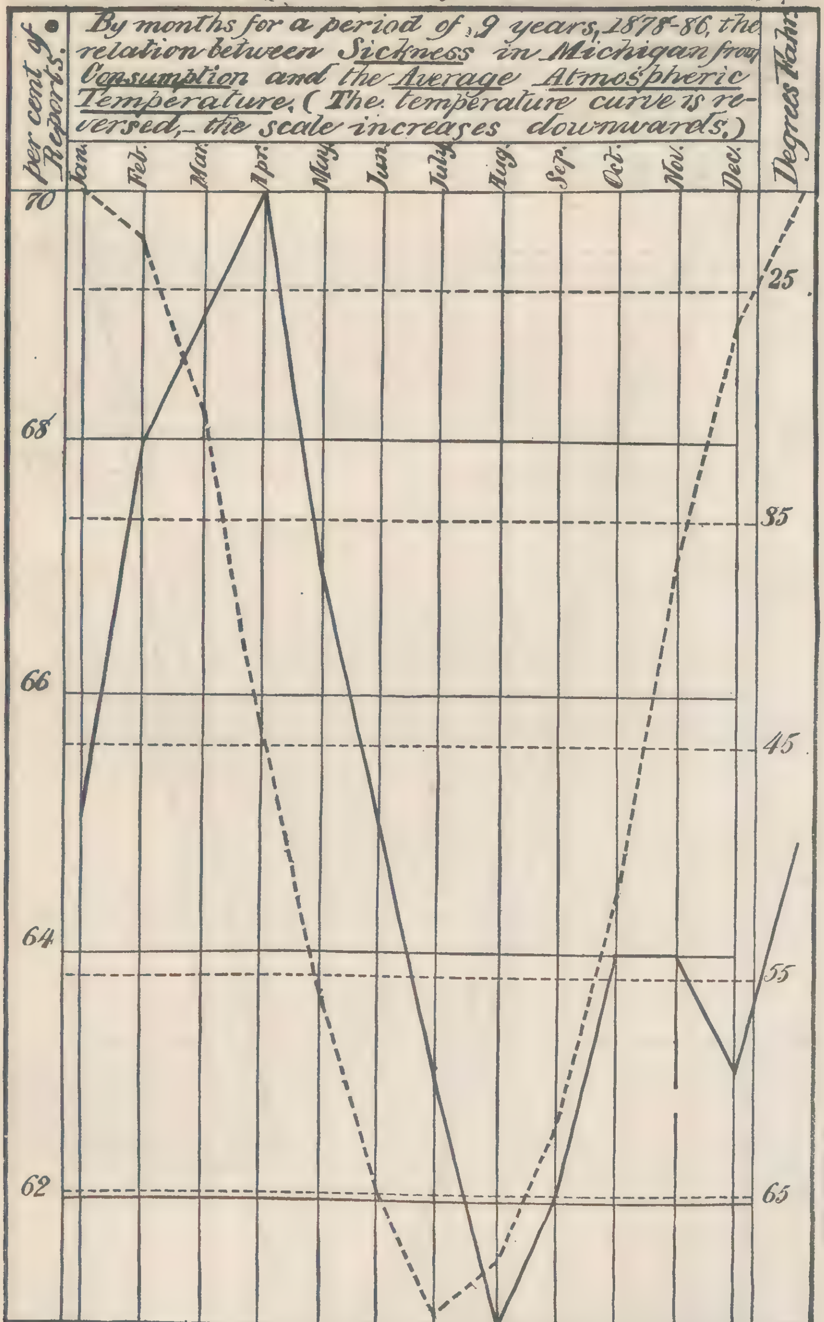
* The temperature curve is made from the normals at six station representing approximately the localities occupied by the Armies of the United States.

No 10 Temperature, and Deaths from Phthisis in London.



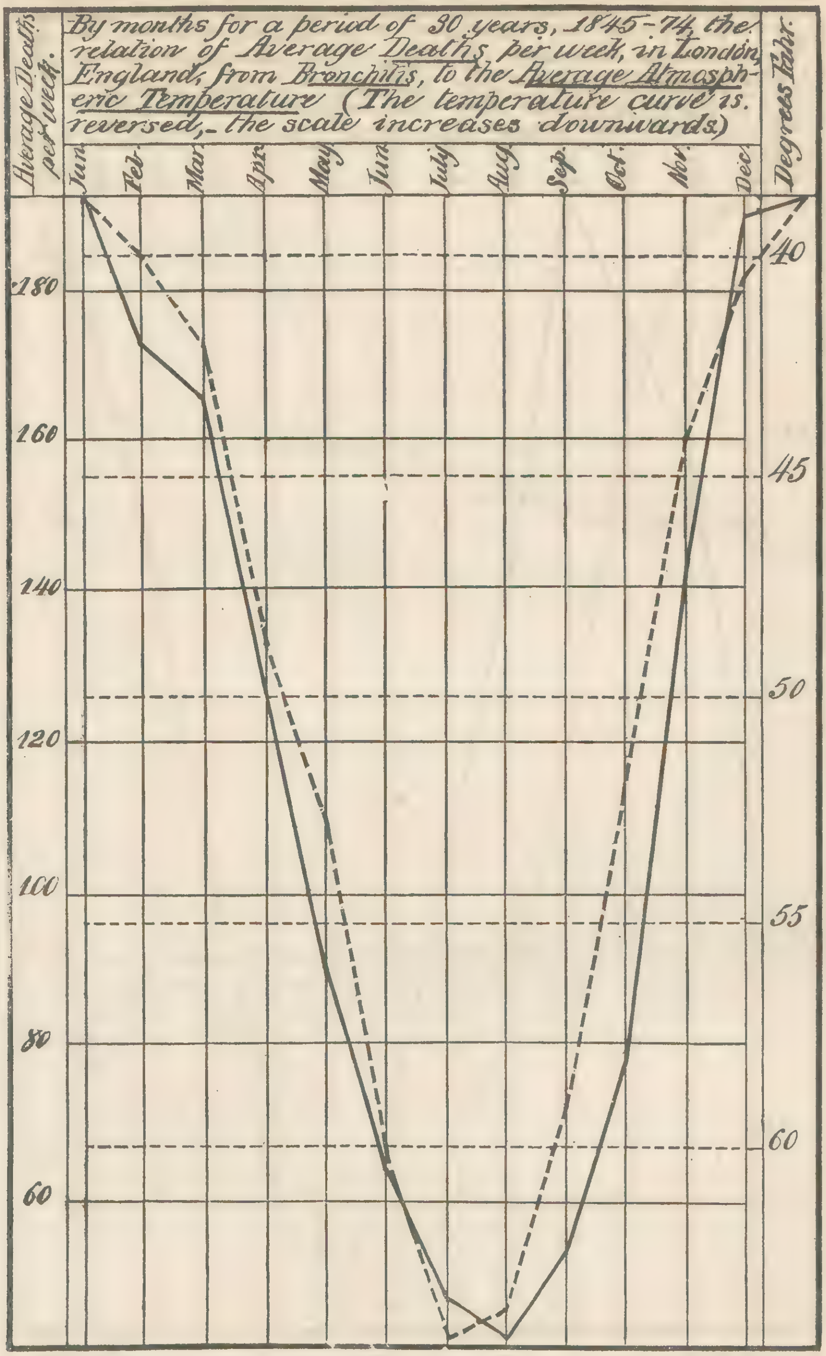
Deaths ———. Average Temperature - - - - - - -
About 231.000 deaths from Phthisis are represented in this diagram data for which are from Jour. of Scottish Met. Soc., New Series Nos XLIII, XLIV, XLV, XLVI, pages 252 and 263.

No 11 Temperature and Sickness from Consumption in Michigan.



Consumption ———— Average Temperature - - -

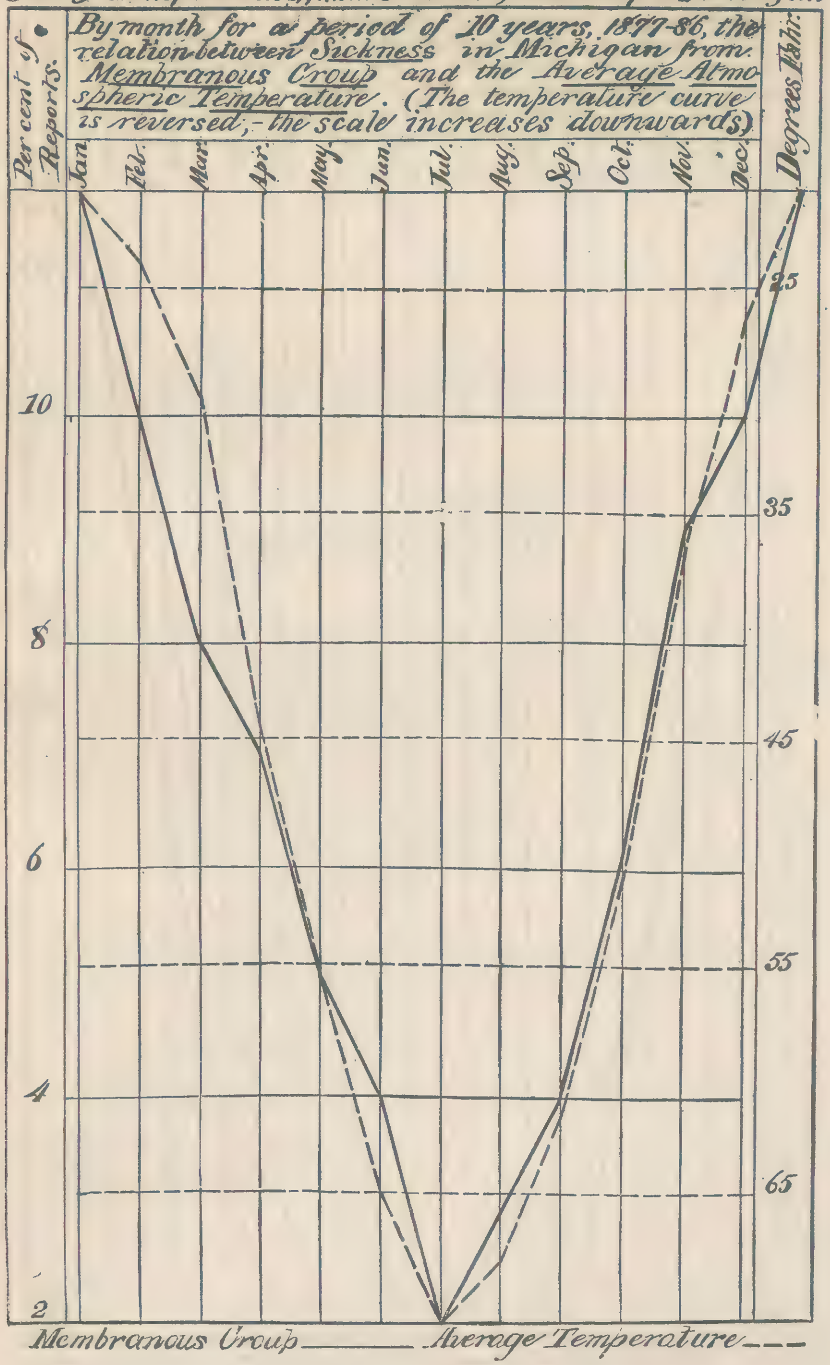
No 12. Temperature and Deaths from Bronchitis in London.



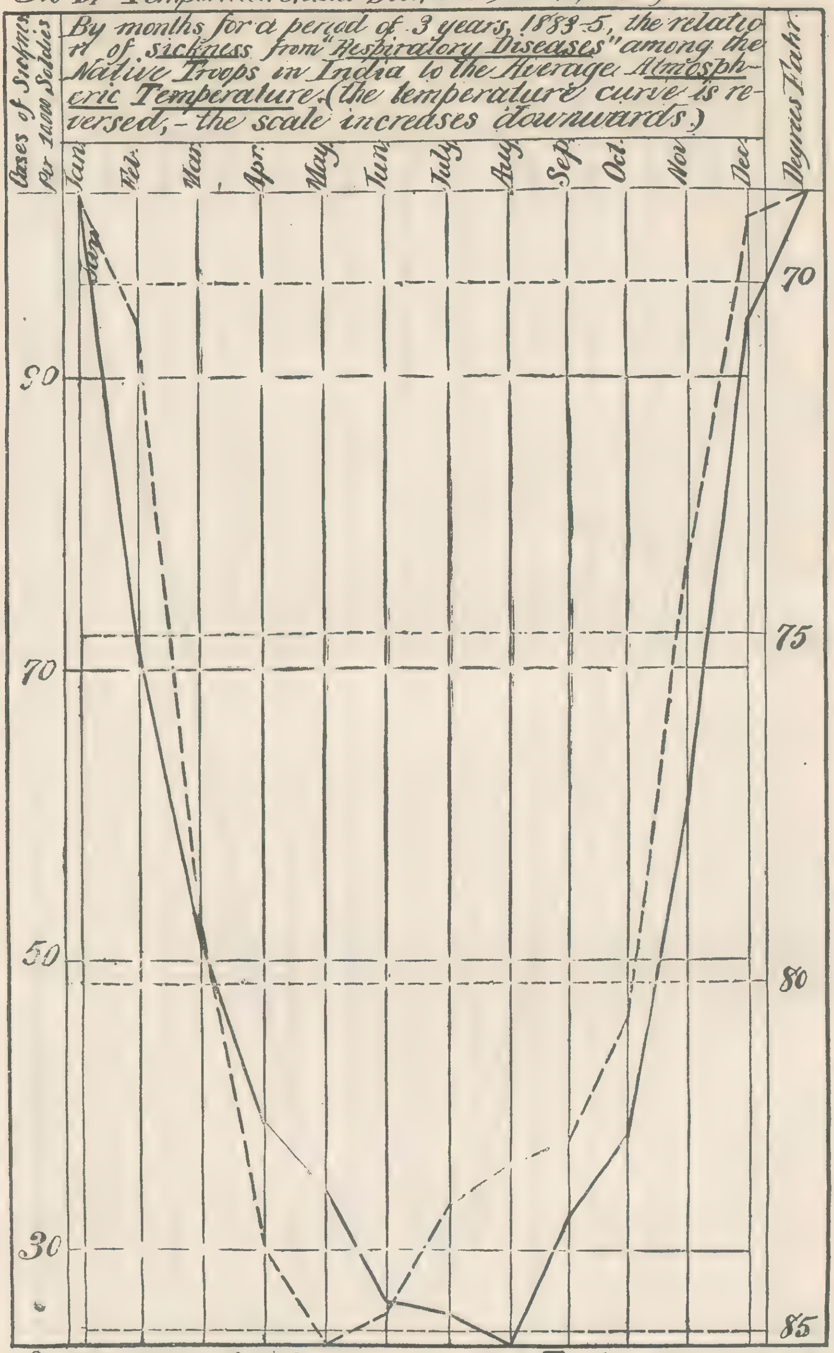
Deaths ———— Average Temperature - - - - -

About 176,000 deaths from Bronchitis are represented in this diagram data for which are from Jour of Scottish Met. Soc. New Series Nos. XIIII., XLIV., XLV, XLVI. pages 253 & 263

No 13 Temperature, and Sickness from Croup in Michigan

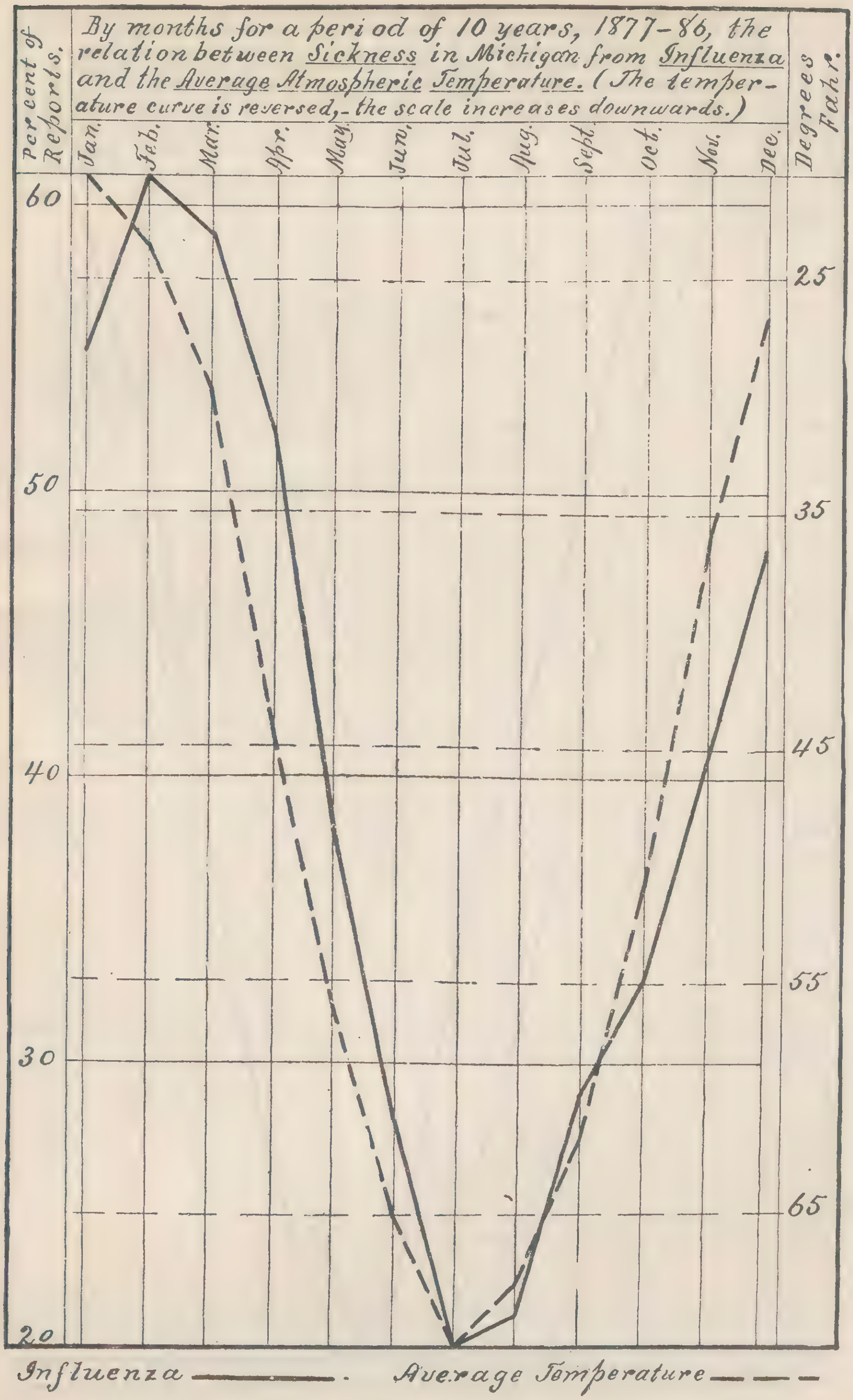


No 14 Temperature and Sickness from "Respiratory Diseases" in India

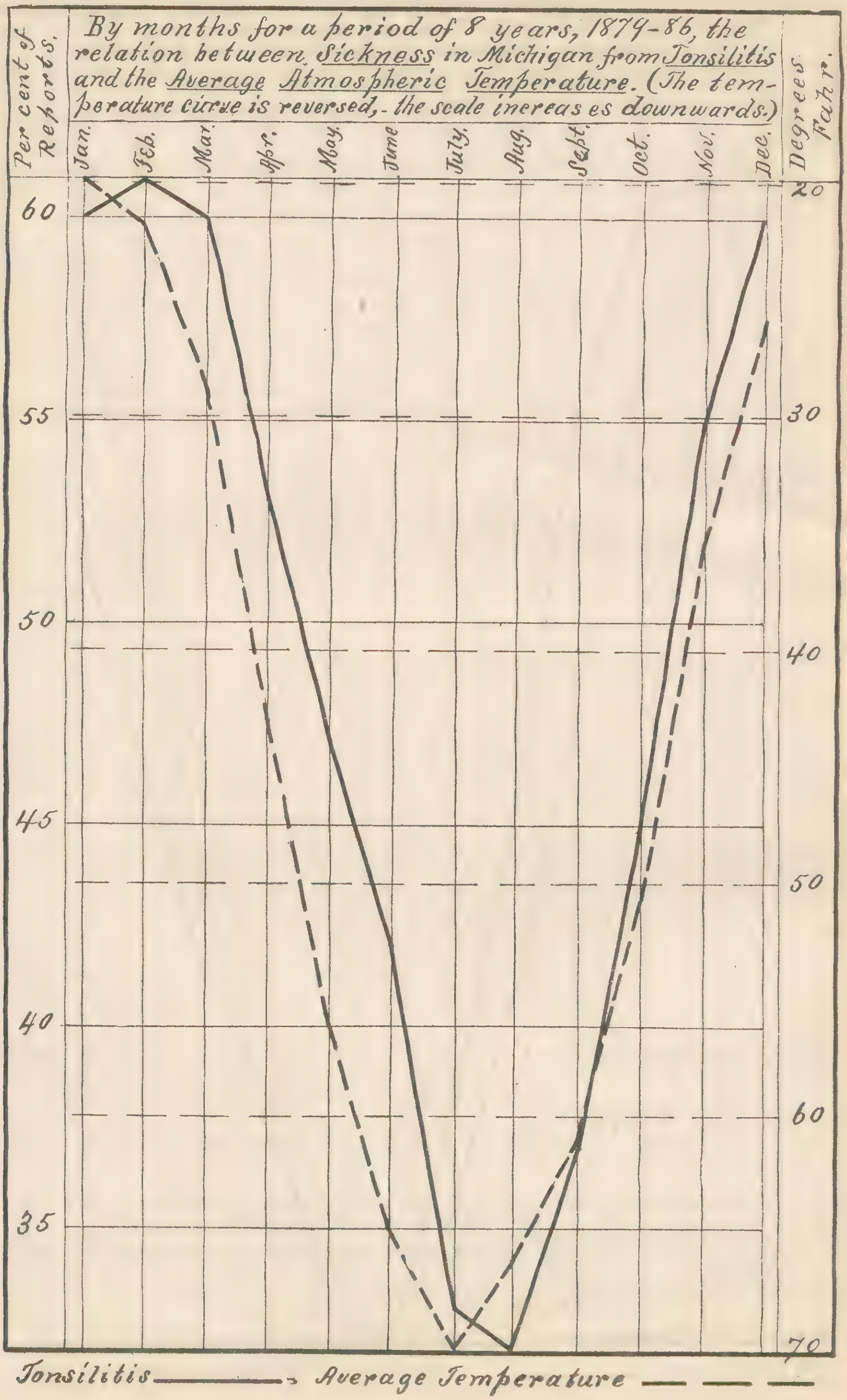


Averag cases of sickness _____ Average Temperature - - - - - -
Prepared from data found in 20th, 21st, and 22nd Annual Reports of the Sanitary Commissioner with the Government in India.

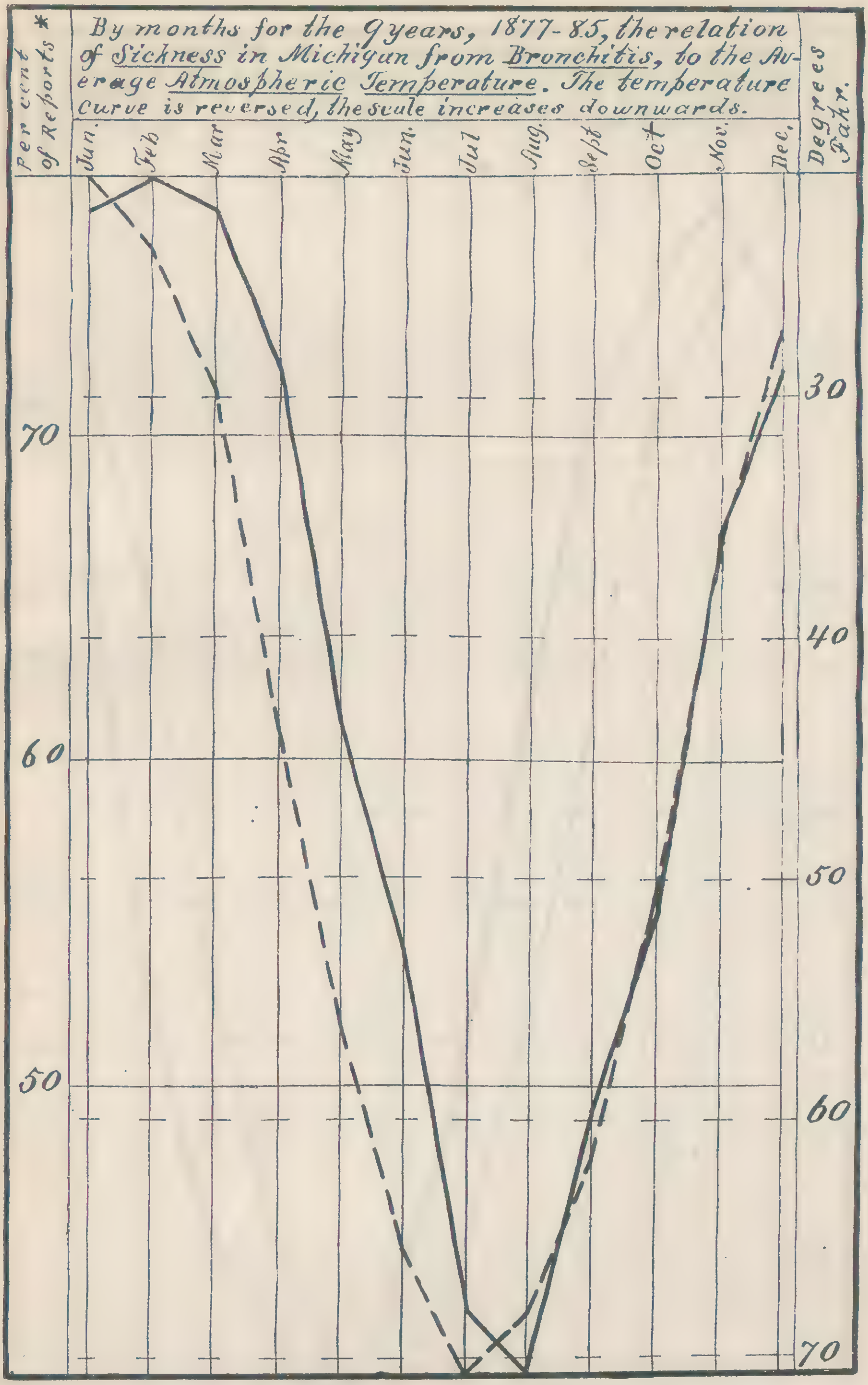
NO. 15.—TEMPERATURE AND SICKNESS FROM INFLUENZA IN MICHIGAN.



NO. 16.—TEMPERATURE AND SICKNESS FROM TONSILITIS IN MICHIGAN.



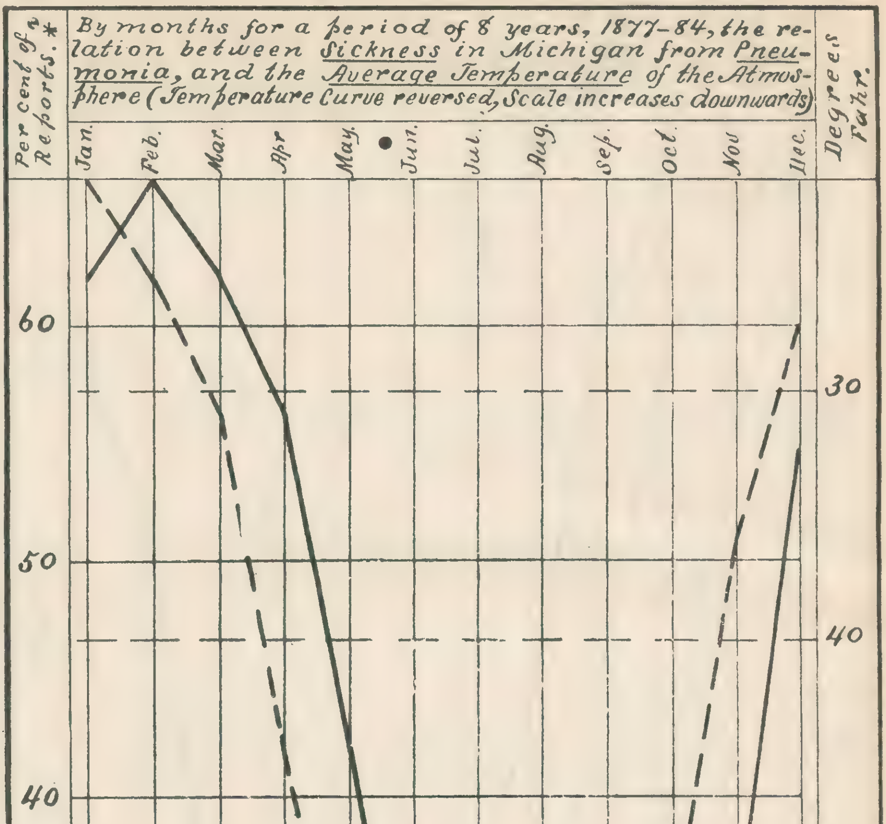
NO. 17.—TEMPERATURE AND SICKNESS FROM BRONCHITIS IN MICHIGAN.



Bronchitis ————. Average Temperature — — —.
* Indicating what per cent of all reports received, stated the presence of Bronchitis then under the observation of the physicians reporting.

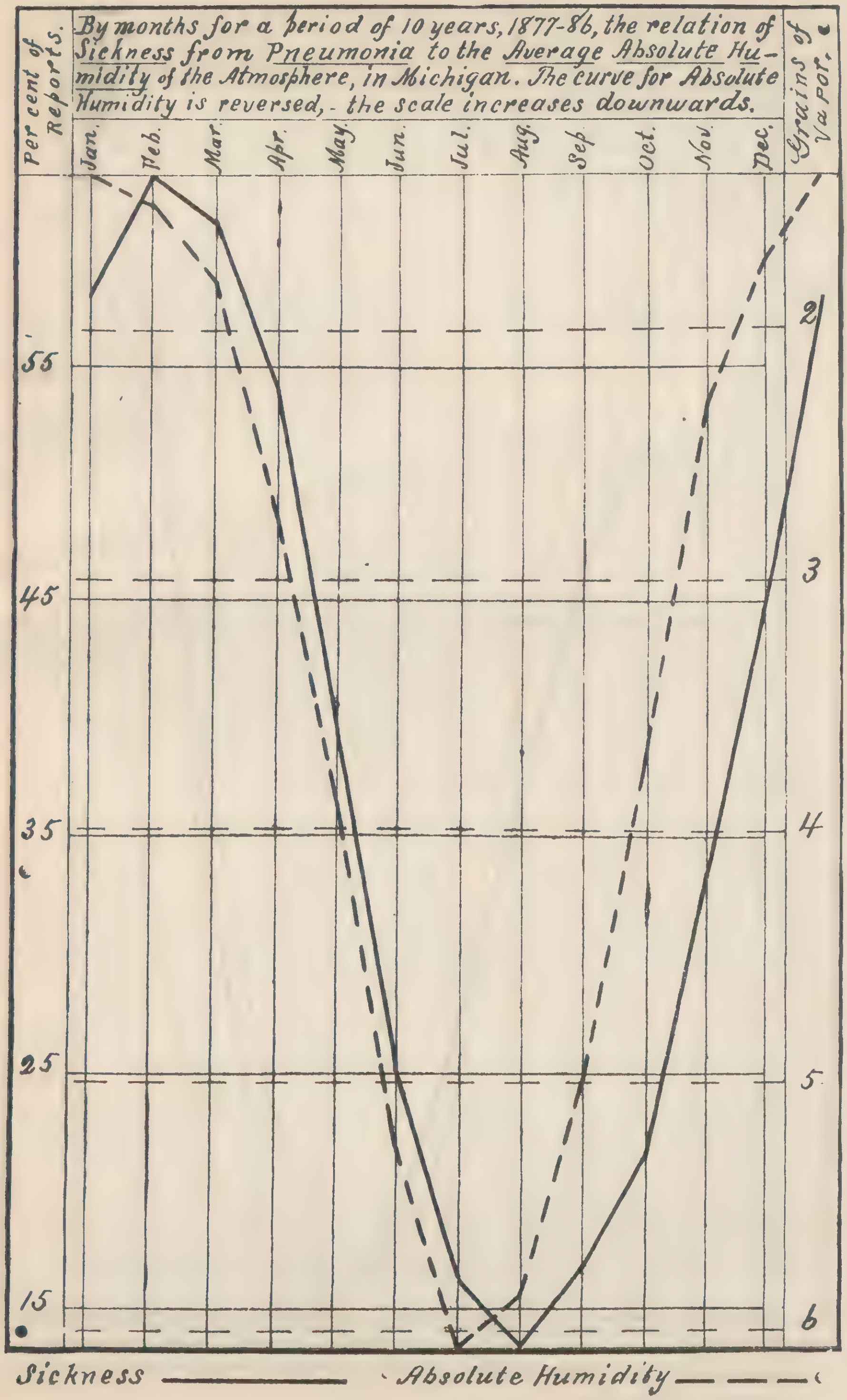
Over 35,000 weekly reports of sickness, and about 173,000 observations of the atmospheric temperature are represented in this diagram.

NO. 18.—TEMPERATURE AND SICKNESS FROM PNEUMONIA IN MICHIGAN.

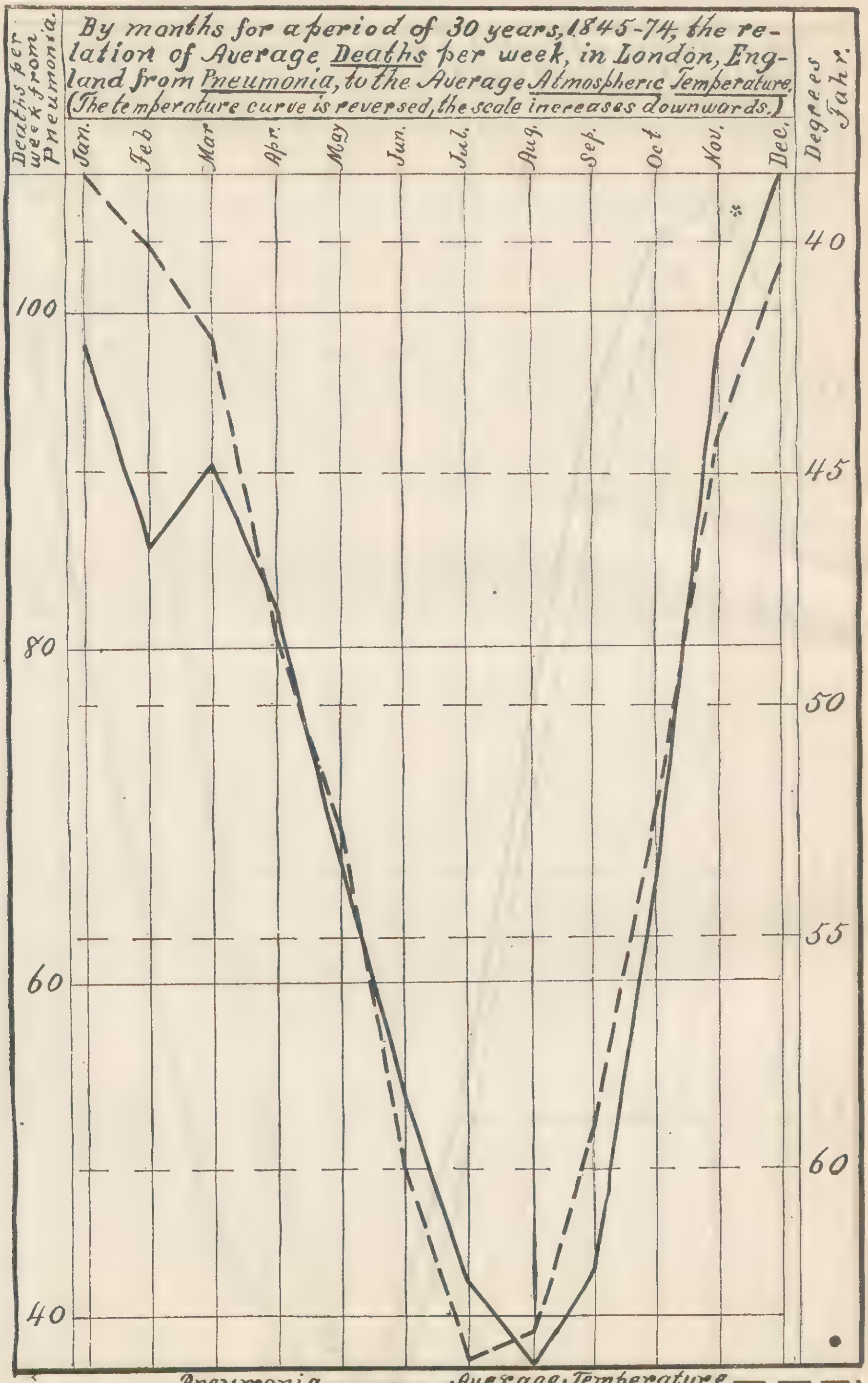


Sickness from Pneumonia ———. Average Temperature — —.
*Indicating what per cent of all reports received, stated the presence of pneumonia then under the observation of the physicians reporting.
Over 30,000 weekly reports of sickness, and over 150,000 observations of the atmospheric temperature are represented in this diagram.

NO. 19.—ABSOLUTE HUMIDITY, AND SICKNESS FROM PNEUMONIA IN MICHIGAN.

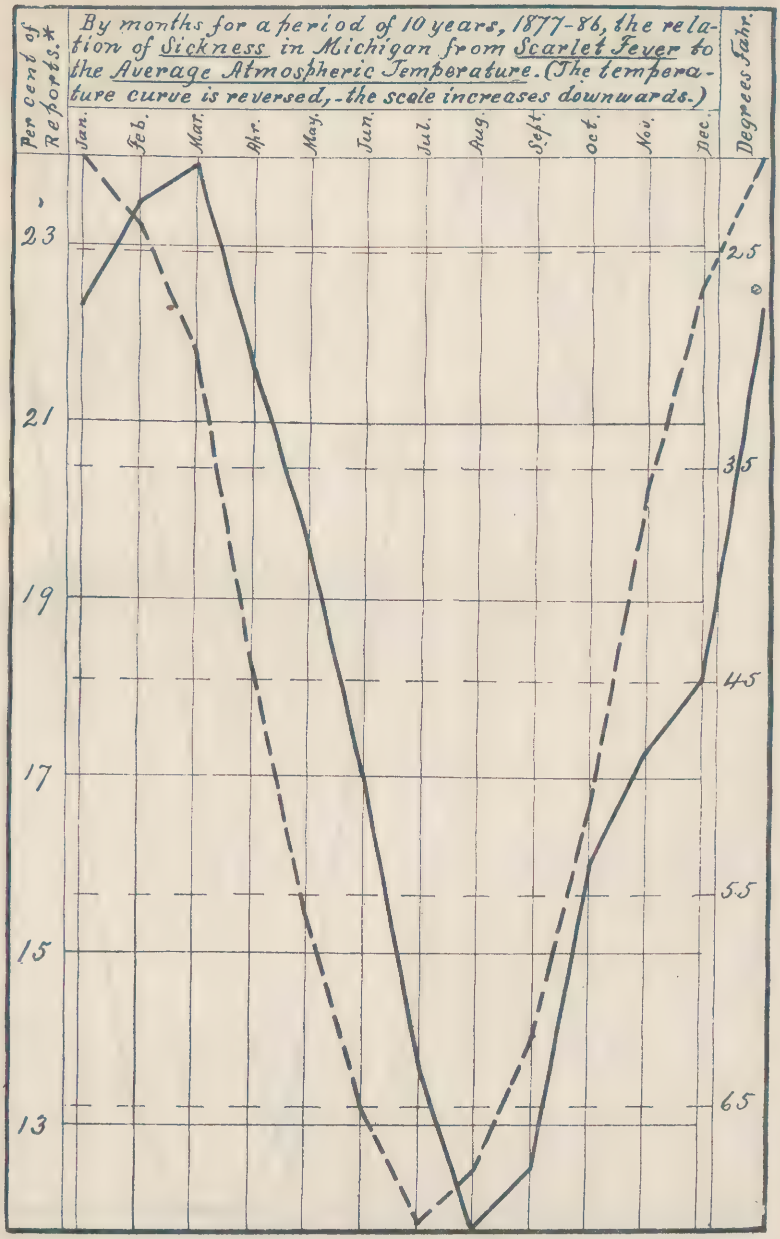


NO. 20.—TEMPERATURE AND DEATHS FROM PNEUMONIA IN LONDON.



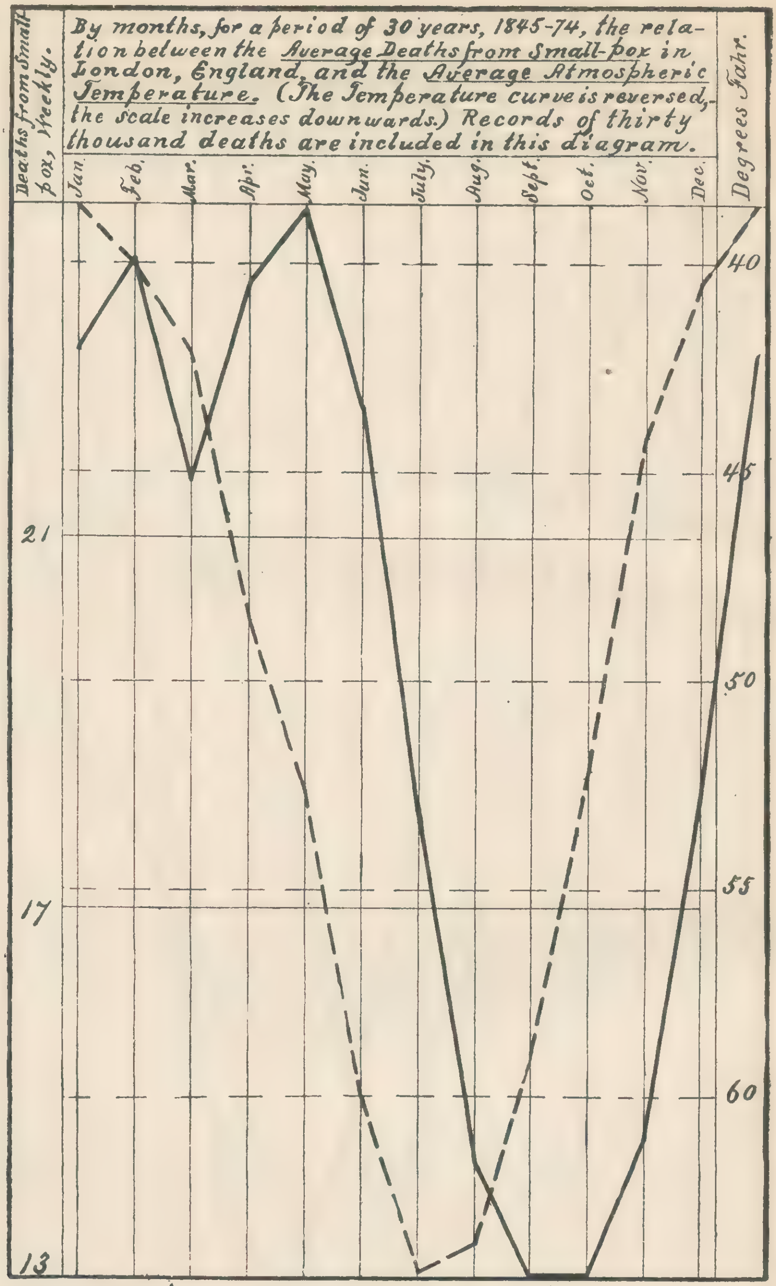
* Perhaps a greater proportion of deaths are returned for the later than for the earlier months in each year?

NO. 21.—TEMPERATURE AND SICKNESS FROM SCARLATINA IN MICHIGAN.



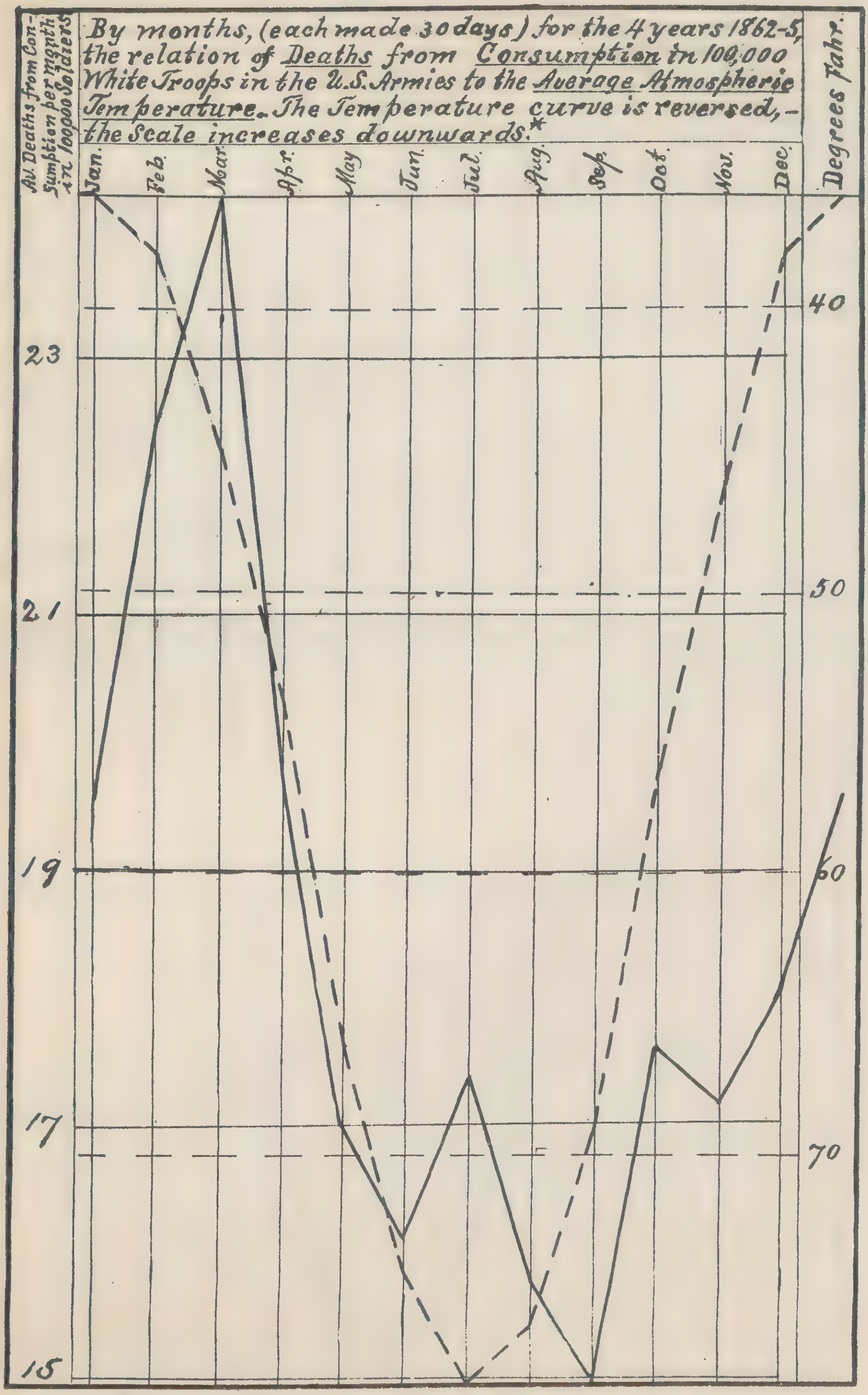
Scarlet Fever ———. Average Temperature — — —.
*Which stated that Scarlet Fever was under the observation of the physicians who made reports.
Over forty-one thousand weekly reports of sickness and over 190,000 observations of the atmospheric Temperature are represented in this diagram.

NO. 22.—TEMPERATURE AND DEATHS FROM SMALL-POX IN LONDON.



Small-pox ———. Average Temperature - - -.
Except in a few months the Small-pox follows two months later than the temperature changes.
The line representing Small-pox should follow as long a time later than a line representing its controlling condition as is the average duration of the fatal cases plus the period of incubation?

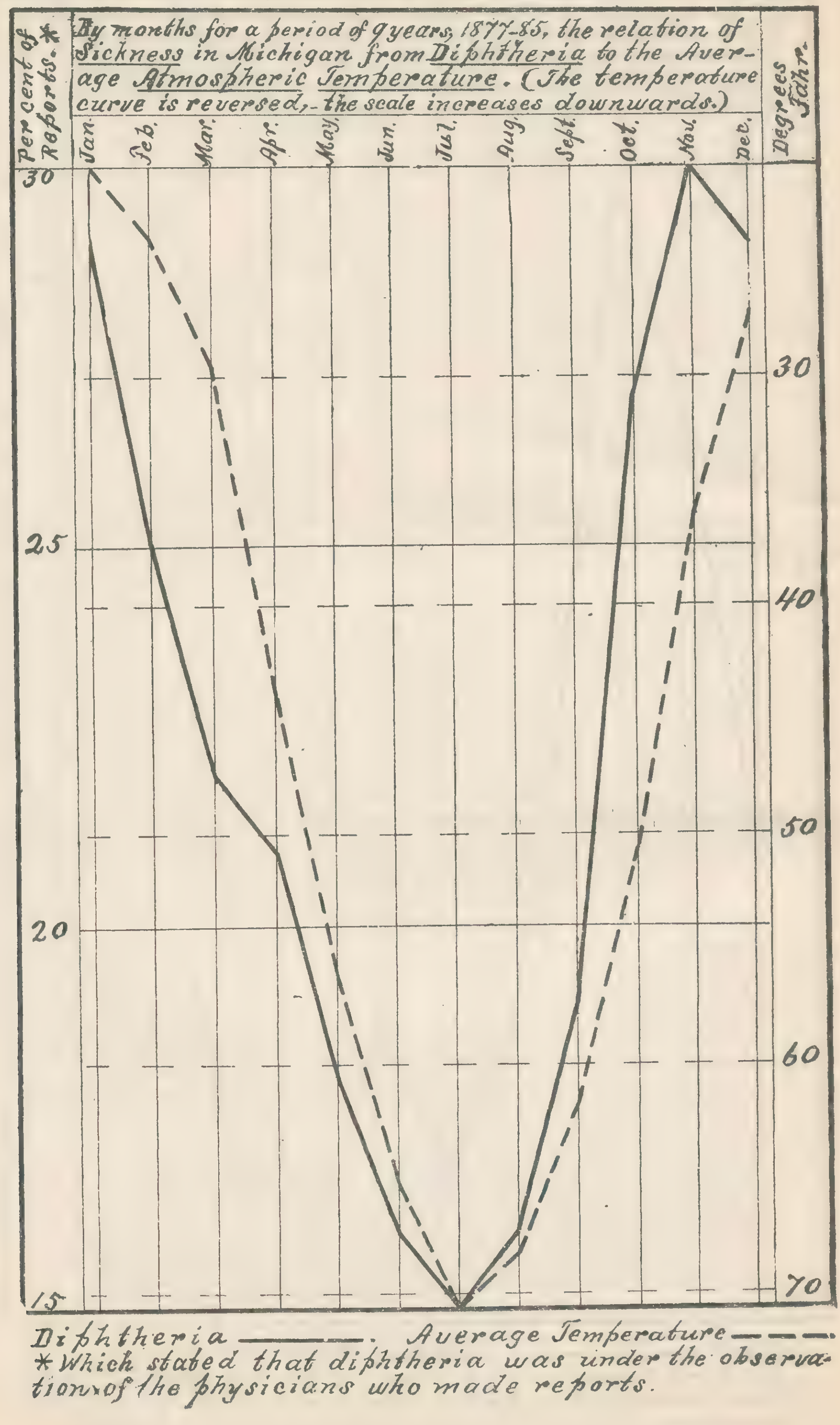
Diagram 23.—Deaths from Consumption in U.S. Armies, and Temperature.



Deaths ————————. Average Temperature — — — .

*The temperature curve is made from the normals at six Stations representing approximately the localities occupied by the armies of the United States in the war of the rebellion.

Diagram 24.–Sickness from Diphtheria, and Temperature in Michigan.



RECENT SAVING OF LIFE IN MICHIGAN.

In a carefully-prepared paper, read before the Sanitary Convention at Vicksburg, the proceedings of which are just published, Dr. Baker gave official statistics and evidence which he summarized as follows :—

"The record of the great saving of human life and health in Michigan in recent years is one to which, it seems to me, the State and local boards of health in Michigan can justly 'point with pride.' It is a record of the saving of over one hundred lives per year from small-pox, four hundred lives per year saved from death by scarlet fever, and nearly six hundred lives per year saved from death by diphtheria—an aggregate of eleven hundred lives per year, or three lives per day saved from these three diseases! This is a record which we ask to have examined, and which we are willing to have compared with that of the man who 'made two blades of grass grow where only one grew before.'"